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OFFICIAL PUBLICATION OF THE AEROSPACE INDUSTRIES ASSOCIATION • WINTER 1985

AEROSPACE REVIEW AND FORECAST 1984/85

Notable views of notable people on aerospace matters...

aerospace perspectives

Thomas G. Pownall, *Chairman, Marietta Corporation, in a speech to the Washington (D.C.) Board of Trade:*

"America remains the world's economic giant—the leading producer of goods and services, the most productive of nations in our factories and on our farms, the Number One exporter to the world, the Number One importer from the world, the technological pacesetter in most of the areas that will drive tomorrow, with industrial and government research and development programs at the forefront in virtually every key discipline. One quarter of all goods and services produced on the face of the Earth is produced in the United States. Our Gross National Product roughly equals the European Economic Community and Japan combined . . .

"Some observers have concluded that we are approaching the end of the long-playing American economic miracle, that we are likely to experience a low-growth, more limited, less competitive economy in the future. On the basis of the full body of evidence, I cannot agree. I do not see this highly talented and educated nation, bursting with energy and confident of its soaring capabilities, sinking into decline.

"What I do see emerging is an increasingly interdependent world here and overseas, served and linked and powered by 21st century technologies developed here and overseas, in which our economies interact more and more to the benefit of all nations. Trade, technology, international investment and finance, and economic development are propelling us toward a "One World" even more encompassing than a former businessman named Wendell Willkie foresaw back in the 1940s. In the political arena, obviously, the One World that Willkie suggested at the height of World War II is far from reality. But the interaction among economies, which he considered the other side of the coin, is a growing reality central to the economic future both here and abroad."

William H. Taft IV, *Deputy Secretary of Defense, in an address to the National Security Industrial Association in Arlington, Virginia:*

"It has become popular in some circles to proclaim the death of American ingenuity—but I don't believe it for a minute. What I do believe is that we sometimes stifle that ingenuity. When cartloads of military standards and specifications are applied *prematurely,* before we have learned what special problems or opportunities may arise during development—or *rigidly,* without tailoring to fit the particular program—or even *inadvertently,* through automatic reference to several subtiers of specification, we incur unnecessary costs . . .

"This is why it is so vital that reducing overspecification be a top-level management priority, both in the Department of Defense and in industry. Our people need to know that they will be rewarded for coming up with inventive ways to improve productivity and meet mission requirements at lower cost; indeed, they need to know that tailoring specifications and standards is a crucial *requirement* of their jobs . . .

"The Department of Defense (has been engaged) in a comprehensive attack on the problem of 'untimely, untailored and accidentally-referenced applications of specifications and standards.' We are already seeing some important results. I am pleased to say we have had first rate cooperation from industry on this initiative . . .

"Allowing industry to have a greater role in identifying the most cost-effective application of specifications and standards is one important step toward improved defense productivity. But we must go further. We must recognize that the defense industry has not escaped the productivity and quality problems that plagued all American industry during the 1970s . . .

"As a partner in the drive to restore defense productivity, DoD is seeking to help industry acquire the tools needed to improve productivity and quality . . . During the coming year we hope to focus on ways that DoD and industry together can motivate and train both management and employees to give priority to quality . . .

"The aim of our productivity initiatives is to give industry the opportunity, the incentive and the tools to produce higher quality products at lower cost. We want to give (industry) more responsibility; we want (industry) to tell us *how* we can achieve what we need. We want to tap the ingenuity and experience of the world's most resourceful and technically capable workforce."

Caspar W. Weinberger, *Secretary of Defense, speaking to the National Press Club, Washington, D.C.:*

"I believe the postwar period has taught us several lessons, and from them I have developed six major tests to be applied when we are weighing the use of U.S. combat forces abroad. . . .

"First, the United States should not commit forces to combat overseas unless the particular engagement or occasion is deemed vital to our national interest or that of our allies. That emphatically does not mean that we should declare beforehand, as we did in Korea in 1950, that a particular area is outside our strategic perimeter.

"Second, if we decide it is necessary to put combat troops into a given situation, we should do so wholeheartedly and with the clear intention of winning . . .

"Third, if we do decide to commit forces to combat overseas, we should have clearly defined political and military objectives, and we should know precisely how our forces can accomplish those clearly defined objectives . . .

"Fourth, the relationship between our objectives and the forces we have committed—their size, composition and disposition—must be continually reassessed and adjusted if necessary . . .

"Fifth, before the U.S. commits combat forces abroad, there must be some reasonable assurance we will have the support of the American people and their elected representatives in Congress . . .

"Sixth, the commitment of U.S. forces to combat should be a last resort . . .

"The point we must all keep uppermost in our minds is that if we ever decide to commit forces to combat, we must support those forces to the fullest extent of our national will for as long as it takes to win."

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1984/1985

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems.

Foster understanding of the aerospace industry's responsibilities in the space exploration program.

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade.

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

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A LOOK AHEAD

BY KARL G. HARR, JR.
President, Aerospace Industries Association

If we use inflation-adjusted sales volume as a yardstick of aerospace industry activity, 1984 was among the best years in the industry's history. In constant dollar terms, it trailed only the peak years 1967-68 when the industry was simultaneously engaged in military production for the Vietnam war and strategic missile programs, large-scale manufacture of commercial transports and fabrication of space equipment for the Apollo lunar landing program.

The high 1984 sales volume was achieved despite the fact that commercial transport sales dipped to the lowest level since 1978. Aerospace Industries Association feels, however, that the decline has bottomed and we look for a sharp rebound this year. That, along with projected increases in defense and space sales, should make 1985 the industry's new all-time record year.

Looking farther down the road, we see continuing high levels of aerospace activity in the coming decade. The world's airlines, although not yet robust, are regaining financial health and are already resuming their deferred reequipment programs. The driving forces are the need to replace older aircraft and, most importantly, to realize the significant operating economies offered by new, advanced technology transports. Forecasts show a very large market for jetliners; even the most conservative estimate exceeds the total of all transports delivered over the past 20 years. If market projections hold up, and if U.S. manufacturers can retain something close to their traditional market share in the face of growing competition, commercial transport production will increase to what could become the highest level ever.

With regard to space business, the most rapidly expanding area of the industry's workload in recent years, Administration plans coupled with indicated growth in commercial space operations suggest substantially higher levels of industry activity in coming years.

The defense business picture is somewhat uncertain. There is considerable evidence that the Administration's defense buildup may be compromised to a degree in view of the great concern about the national deficit. But pre-election polls and the outcome of the election have made it clear that a majority of the American people back President Reagan's security policies. In Congressional deliberations, no one is talking seriously of reducing defense outlays *below* current levels; the debate centers on whether or how much the defense budget should be increased. Thus, we anticipate moderate increases in defense spending—hence industry activity—throughout the Reagan Administration.

In summary, the industry's business prospects for the next decade must be rated good to excellent, because we see activity gains in two major areas of workload where we are already strong—defense and space—and, in the one area where business has been depressed in recent years—commercial transport manufacture—we look for an upswing beginning this year.

AEROSPACE HIGHLIGHTS 1984

By JAMES J. HAGGERTY

DEFENSE

In September, House and Senate conferees approved production of 21 additional Peacekeeper (MX) intercontinental missiles—on top of 21 already in production—but froze funding for the new weapons until each chamber of Congress reapproves the program this year.

Meanwhile, the Peacekeeper flight test program continued with four successful flights in 1984 from Vandenberg Air Force Base, California. The last of the four, on October 1, was the sixth Peacekeeper test, including two in 1983; it was a realistic simulation of an operational mission covering a flight of more than 4,700 miles. In 1985, Peacekeeper was to begin a new phase of testing in which the missiles will be launched from Minuteman test silos at Vandenberg. The USAF plans a total of 20 test flights; initial operational capability was targeted for late 1986.

Major Peacekeeper contractors include Martin Marietta Aerospace (assembly and test); Rockwell Autonetics (guidance and computers); Northrop (inertial guidance system); Morton Thiokol (first stage); Aerojet-General (second stage); Hercules Incorporated (third stage); Rockwell Rocketdyne (fourth stage); Avco Corporation and General Electric Company (re-entry systems); Westinghouse (missile canister); Boeing (support equipment); TRW Inc. (engineering and technical support); and Honeywell Inc. (guidance and control elements).

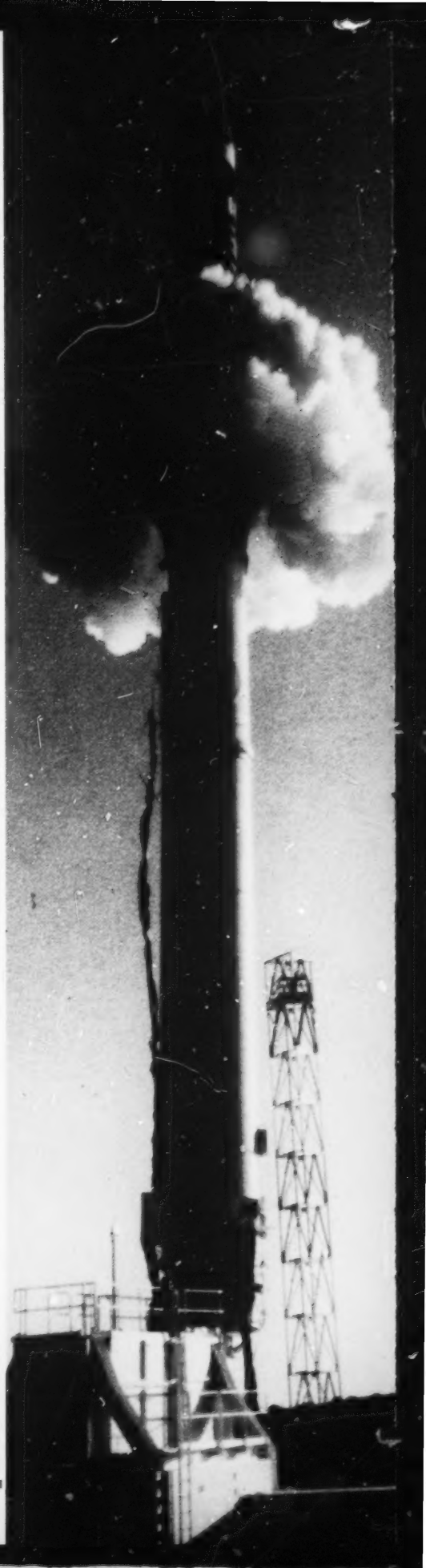
Development continued on the Air Force's Small ICBM program with award of study contracts for propulsion and launch systems. Aerojet-General, Hercules, Morton Thiokol and United Technologies received contracts to study boost systems; Bell Aerospace, Boeing, General Dynamics and Martin Marietta won contracts for study of mobile launch systems. Full-scale development of the Small ICBM was planned for 1986, with flight testing to begin in 1988.

In April, the USAF formed a separate Strategic Defense Initiative (SDI) Organization to manage the antiballistic missile defense research program. Funded at $1.5 billion for 1985, SDI is one of the largest Department of Defense R&D programs; it is a study and technology development effort intended to explore a variety of space-based, aircraft-based and ground-based missile defense possibilities toward eventual definition of an antiballistic missile defense system.

Engineering development of the Trident II submarine-launched ballistic missile continued in 1984. The Navy awarded contracts for development and production of the first 52 missiles to Lockheed Missiles & Space Company (prime contractor), Westinghouse Electric Corporation (launcher subsystem) and General Electric Company (fire control system). Deployment of Trident II is planned for 1989. In 1984, the Lockheed-built Trident I was in operational status aboard Trident-class nuclear submarines.

Deployment in Europe of the Army/Martin Marietta Pershing 2 ballistic missile continued in 1984, as did developmental flight testing. At Cape Canaveral, Florida, the Army Missile Command conducted four environmental test launches of Pershing 2 in which the missile was alternately exposed to unusual pre-launch levels of heat and cold.

The Tomahawk cruise missile was in development and production in several different versions produced by prime contractor General Dynamics and second source associate contractor McDonnell Douglas; the latter company delivered its first production missiles. Deployment of the Tomahawk GLCM (Ground Launched Cruise Missile) in NATO countries continued in 1984. Operational tests of the SLCM (Sea Launched Cruise Missile) were completed and deployment of the weapons on submarines was initiated. The TLAM-N (Tomahawk Land Attack Missile-Nuclear) was declared operational in June but not officially deployed at sea due to a Congressional moratorium on deployment. The conventional-warheaded TLAM-C was flight tested with live warheads and in "pop up" maneuvers involving vertical terminal dives for more accurate attack, tests not previously accomplished. General Dynamics was also working under



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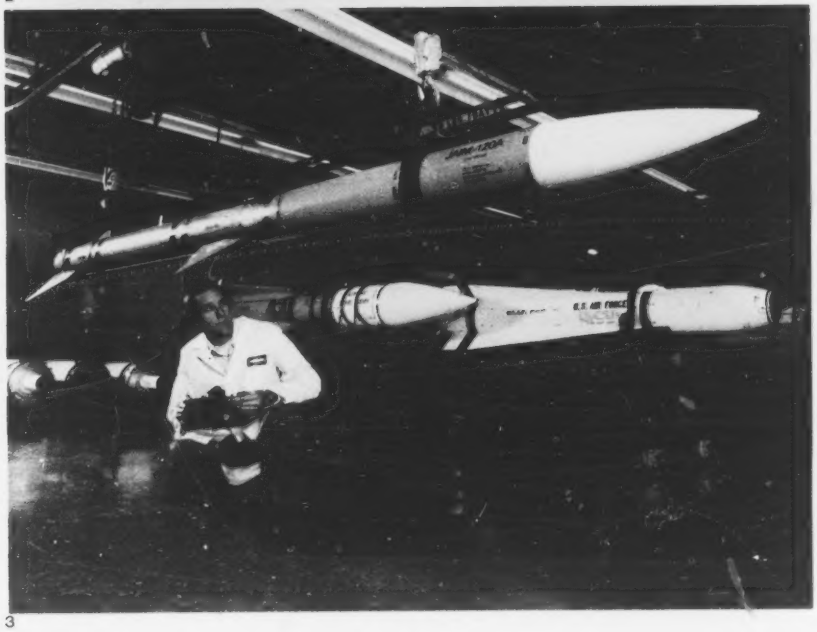

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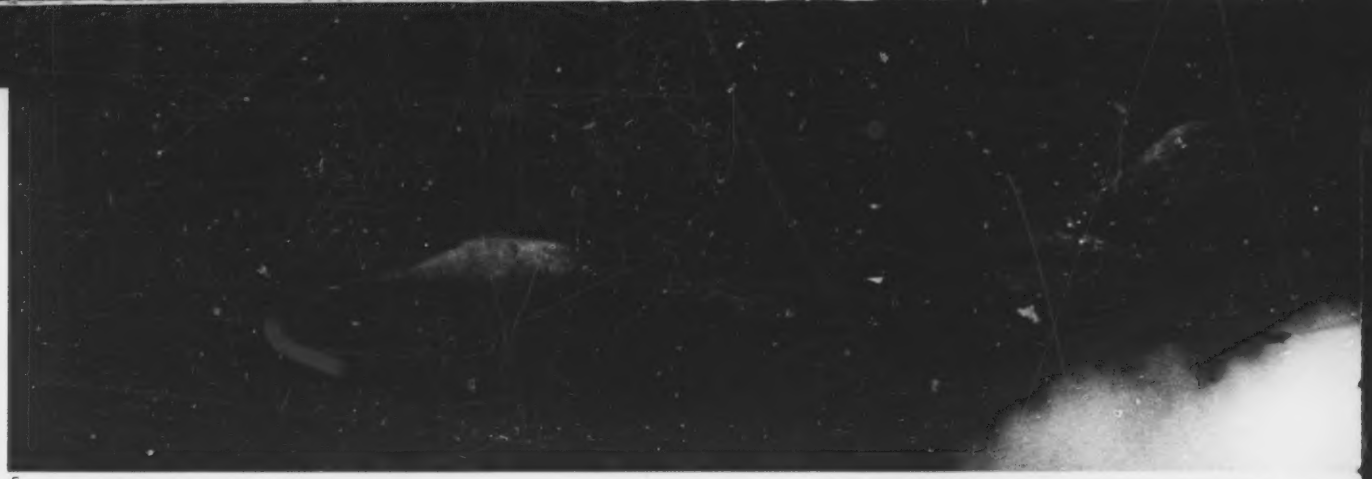
1. The USAF conducted four successful tests of the four-stage Peacekeeper intercontinental missile in 1984; 14 additional tests were planned.
2. The Tomahawk cruise missile was in development and production in several versions. The version pictured is the Navy's Sea Launched Cruise Missile, shown being fired from a launcher on the deck of a destroyer.
3. In December, the first production model of the AMRAAM (Advanced Medium Range Air-to-Air Missile) was test flown.
4. The RAM (Rolling Airframe Missile), a fast-reaction Navy shipboard defense weapon, completed a series of development tests.



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Air Force contract on an Advanced Cruise Missile intended as a complementary system to the Boeing-built ALCM (Air Launched Cruise Missile). Production of the latter weapon was completed and the USAF announced plans for upgrading the 1,700 ALCM's with retrofits.

In other 1984 missile developments,

• The Air Force conducted the first two of a planned 12 flight tests of the experimental Miniature Homing Vehicle antisatellite system, one in January and one in November. The USAF withheld details. LTV Aerospace and Defense Company is ASAT contractor.

• The RAM (Rolling Airframe Missile), a joint U.S.-West Germany shipboard defense system, completed a series of development tests and was being readied for operational tests at sea. General Dynamics is the U.S. contractor.

• Testing continued on the Hughes-built AMRAAM (Advanced Medium Range Air-to-Air Missile) and, in December, the first production model of the missile was test flown at White Sands Missile Range, New Mexico.

• In January and November, the Army conducted successful tests of the LTV Aerospace SHRIT (Small Homing Rocket Interceptor Technology) missile, simulating trajectories to intercept re-entry vehicles.

The year's highlight in military aircraft development was the successful initial flight—in October—of the first production model B-1B, built by Rockwell International for the Air Force. The B-1B was scheduled for initial operational capability late in 1986. Among other military aircraft highlights:

• In October, the Air Force awarded a contract to McDonnell Douglas for development of an advanced technology F-15 STOL (Short Takeoff and Landing) demonstrator. First flight was targeted for 1988.

• In July, General Dynamics started deliveries of the F-16C, an improved version of the F-16A USAF fighter. In September, the company received a contract to modify an airplane for feasibility flight tests of a reconnaissance version of the F-16.

• In August, the Navy began testing of a McDonnell Douglas F/A-18 modified for use as a reconnaissance aircraft. The fighter version of the F/A-18 passed its first tests with an operating squadron aboard an aircraft carrier.

• Development of the USAF/ McDonnell Douglas C-17 military transport progressed with completion of mockup-based tests involving loading and unloading of heavy equipment, including trucks, tanks and helicopters. A decision as to whether the Department of Defense would proceed with full-scale development of the C-17 was expected early in 1985.

• The X-29A research airplane, which incorporates a foreswept wing and a number of other advanced technologies, made its first flight in December.

• In March, Gates Learjet Corporation rolled out the first of 80 C-21A operational support aircraft being built for the Air Force. The C-21A is a military version of the Learjet 35A business/utility transport.

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• The Navy initiated development of an improved Grumman F-14D with an advanced engine, new radar and all-digital avionics.

• In November, Northrop Corporation started construction of another F-20 tactical fighter demonstrator to join the two already in the flight test program.

• At year-end, Boeing was completing work on the first model of a new EC-18B ARIA (Advanced Range Instrumented Aircraft), an airborne tracking station for support of missile and space tests. The EC-18B, a modified Boeing 707, is a stretched version of the existing ARIA.

• In August, the Army/Hughes Helicopters AH-64 attack helicopter made first firings of laser-guided Hellfire missiles using a production model target acquisition system developed by Martin Marietta Orlando Aerospace. Deliveries of the AH-64 reached 16; Hughes Helicopters had orders for an additional 144.

• In July, Bell Helicopter Textron delivered the first five prototype OH-58D helicopters in the Army Helicopter Improvement Program. The upgraded AHIP helicopter incorporates new sensors, displays, controls and dynamic components. Bell was in production on 16 OH-58D helicopters; the Army plans a large-scale, seven-year procurement program.

• First fleet shipboard operations of the Navy-Sikorsky/IBM SH-60B LAMPS (Light Airborne Multipurpose System) Mark III helicopters were conducted in the summer.

• Sikorsky's HH-60D USAF search and rescue helicopter made its first flight in February. Following completion of a series of tests, the prototype was ferried to IBM for installation of avionics equipment and a series of avionics test flights.

• In engineering development status was the Joint Services Vertical Lift Aircraft (JVX), a Navy-managed program for a tilt-rotor transport/utility aircraft intended for service in the 1990s. Contractors are Bell Helicopter Textron, which built the XV-15 prototype from which the JVX derives, and Boeing Vertol Company.

5. The first production model of the USAF B1B bomber made its initial flight in October.

6. In October, the USAF started development of a STOL version of the F-15 fighter.

7. Deliveries of the F-16C, an improved version of the Air Force fighter, began in July and development of a reconnaissance version was initiated.

8. Gates Learjet delivered the first of 80 C-21A operational support aircraft to the Air Force in March.

9. The X-29 A research airplane, featuring a foreswept wing, flew for the first time in December.

10. Operational testing of the Army's AH-64 attack helicopter included firings of the Hellfire antitank missile.

SPACE

For the National Aeronautics and Space Administration, 1984 was highlighted by five successful Space Shuttle missions, including the first retrievals of orbiting satellites.

The Shuttle year began with flight 41-B in February, primary objective of which was to check out the Manned Maneuvering Unit (MMU), built by Martin Marietta Aerospace, a backpack propulsion/ guidance system that enables astronauts to operate in space outside the Shuttle Orbiter. Astronauts Bruce McCandless and Robert L. Stewart, with MMUs strapped over extravehicular space suits developed by United Technologies' Hamilton Standard division, became the first "human satellites;" untethered to the Orbiter *Challenger,* they flew as far as 300 feet from the Orbiter.

The success of 41-B, the 10th Shuttle flight, set the stage for 41-C in April. One of the most spectacular Shuttle missions, 41-C involved recapture and repair of the Solar Maximum Mission spacecraft; launched in 1980 for continuous long-term observation of solar flares, Solar Max had malfunctioned in 1981. On 41-C, astronaut George Nelson flew his MMU to a rendezvous with Solar Max, stabilized it, then maneuvered it back to the Shuttle Orbiter. He and James van Hoften stowed the satellite in the cargo bay and replaced the malfunctioning module with a new one. Solar Max was then redeployed in orbit to continue its solar observations, a dramatic demonstration of Shuttle utility.

In August, NASA launched the Orbiter *Discovery* on mission 41-D with the heaviest payload thus far carried by the Shuttle, including more than 30,000 pounds of commercial communications satellites. The crew successfully deployed the three Hughes-built satellites: Leasat, a military communications system; Satellite Business Systems' SBS-4; and AT&T's Telstar 3-C. The launch of SBS-4 marked the return to Shuttle service of the McDonnell Douglas/Thiokol PAM (Payload Assist Module) upper stage booster after correction of problems experienced earlier in the year. Mission 41-D carried the first commercial astronaut, McDonnell Douglas Astronautics' Charles Walker, who operated the company's electrophoresis system for processing pharmaceuticals in space. The flight also featured the first space test of a large, lightweight, foldable solar array built by Lockheed Missiles & Space Company; the 105-foot-long structure was repeatedly deployed and retracted, demonstrating the practicability of using king-size solar wings as power sources for extended Shuttle missions, for the space

1. On an April Shuttle flight, astronaut George Nelson is flying a Manned Maneuvering Unit to retrieve the Solar Maximum Mission spacecraft.
2. November's Shuttle spectacular: astronaut Joe Allen maneuvers the previously stranded Palapa-B2 commercial communications satellite into the Orbiter's cargo bay; the Westar 6 comsat was retrieved on the same mission.
3. Two Leasat defense comsats were Shuttle-launched, one in August, one in November.
4. Three AMPTE scientific satellites are being prepared for August launch aboard a single Delta booster.
5. Shown being readied for shipment is a Spacenet commercial communications satellite, one of four in the GTE Spacenet network. The first two were launched in May and November.

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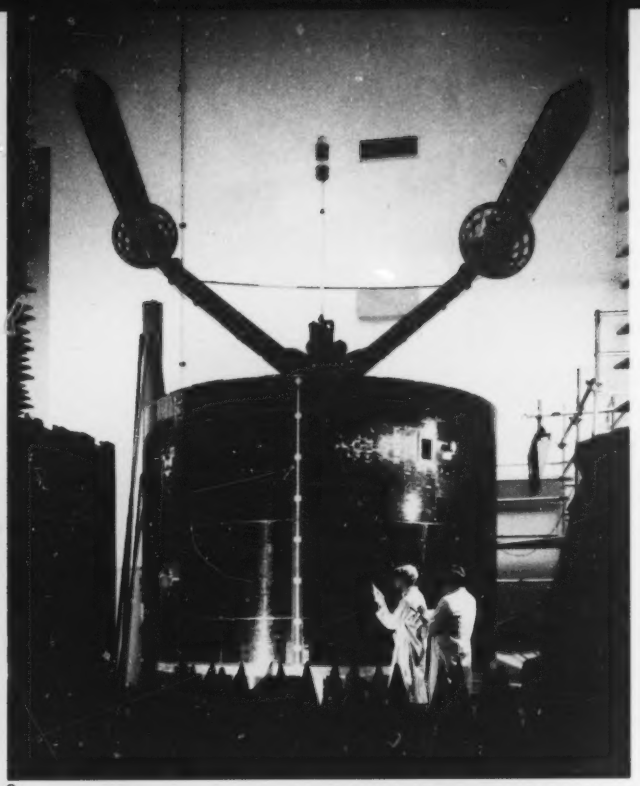

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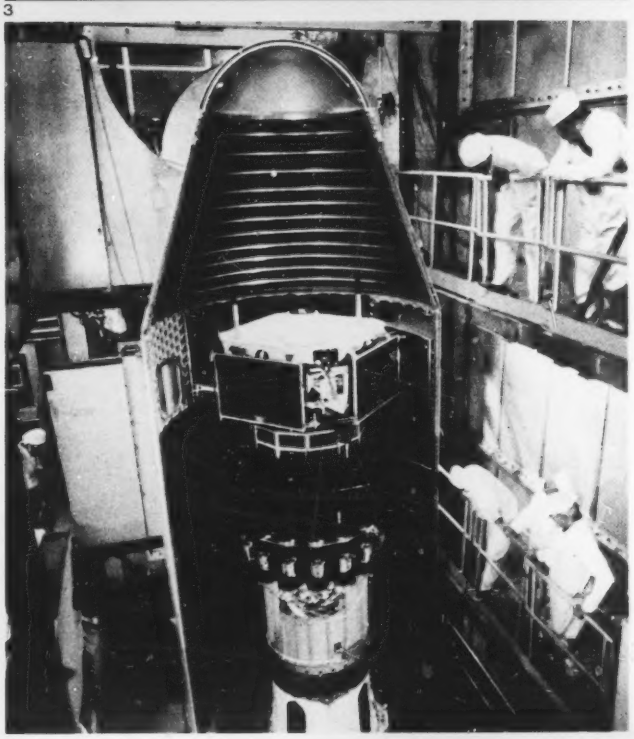

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station and for large unmanned orbiting platforms.

Launched in October, flight 41-G included tests of the advanced SIR-B Shuttle Imaging Radar, deployment of the Earth Radiation Budget Satellite, tests of Shuttle-based hardware for refueling satellites in orbit, and mapping Earth's surface with a new, high resolution Large Format Camera.

Mission 51-A in November was highlighted by retrieval and return to Earth of Palapa-B2 and Westar 6, Hughes-built communications satellites that had been sent into useless orbits on Flight 41-B. Astronauts Joseph P. Allen and Dale Gardner recaptured and stowed the satellites for return to Earth and refurbishment for reuse. Prior to the retrieval operation, the crew successfully launched two other commercial communications satellites, the SPAR-built Anik 2 and a second Hughes Leasat. Mission 51-A closed out a Shuttle year that demonstrated conclusively the versatility and operational effectiveness of the Space Shuttle system. Rockwell International is Shuttle prime contractor.

In addition to the Shuttle-launched payloads, other civil satellites delivered to orbit during the year included:

- Landsat 5, fifth and most advanced of the Earth resources observation satellites built by General Electric Company's Space Division. NASA launched it in March with a McDonnell Douglas Delta vehicle.
- A team of three AMPTE (Active Magnetospheric Trace Particles Explorers), one each supplied by the U.S., West Germany and the United Kingdom. Designed to study how plasma—electrified gas—is transported through the magnetosphere, the satellites were sent into orbit aboard a single NASA Delta in August.
- The RCA-built Spacenet 1 and 2, first two of four satellites in a commercial communications network operated by GTE Spacenet Corporation. They were launched by the European Ariane in May and November.
- A Hughes Galaxy business communications satellite, operated by Hughes Communications, Inc., launched in September by a NASA Delta.
- The NOAA-9 meteorological satellite, another in the network of environmental spacecraft operated by the National Oceanic and Atmospheric Administration. Built by RCA Astro-Electronics, it was launched in December by a General Dynamics Atlas vehicle.

In non-launch NASA activity, the Voyager 2 interplanetary spacecraft continued to function well on its journey through the solar system to an encounter next year wth the planet Uranus. Orbiting the Sun at a distance of some two billion miles, Uranus has never been visited by spacecraft and has been ob-

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6. Late in the year, NASA started evaluation contractor proposals for space station design.

7. The artist's concept shows the Galileo Jupiter-exploration spacecraft and its Centaur booster after release from the Shuttle Orbiter. Galileo will be launched next year.

8. In development for service in the 1990s is a major astronomical observatory, the Advanced X-ray Astrophysics Facility.

served only dimly by Earth telescopes.

Another NASA spacecraft, the International Cometary Explorer, was en route to an encounter—in September of this year—with the Comet Giacobini-Zinner; it will be the first close encounter with a comet. NASA was also preparing for observation of Comet Halley beginning early next year. NASA will have no close encounter spacecraft—as will the Soviet Union, Japan and the United Kingdom—but it will make extensive observations from a distance with its Hughes-built Pioneer Venus Orbiter, Solar Max, the International Ultraviolet Explorer and a new Shuttle-based three-telescope observatory called Astro.

At year-end, NASA was evaluating bids from more than 100 companies and research organizations and preparing to award a series of contracts for definition of various aspects of the space station and associated vehicles, such as the Orbital Transfer Vehicle and Orbital Maneuvering Vehicle. The contracts were to cover 18 months of study and definition work, after which NASA will select contractor teams for hardware development of several "packages"—space station structures, modules, power and control systems, on-board equipment and automated free-flying platforms that will complement space station operations.

Among other major NASA development programs active in 1984 were:

• Galileo, a two-in-one spacecraft system—one element an orbiter, the other an atmospheric probe—for advanced exploration of Jupiter, set for launch in May of next year. In a late 1984 modification to the flight plan, NASA included an option to make the first close fly-by of an asteroid en route to Jupiter; final decision on exercising the option will be made after launch. Jet Propulsion Laboratory is building the Galileo orbiter; Hughes Aircraft and General Electric are teaming on probe development.

• The Hubble Space Telescope, an orbiting observatory capable of expanding man's view of the cosmos 350 times in comparison with existing ground-based telescope systems. The observatory will be Shuttle-launched in 1986. Lockheed Missiles & Space Company is NASA's prime contractor for the spacecraft, Perkin-Elmer Corporation for the optical assembly.

• The Venus Radar Mapper, which will penetrate Venus' cloud cover to map in greater detail than was earlier accomplished 90 percent of the planet's surface. To be launched in 1988, it is being developed under Jet Propulsion Laboratory management by Martin Marietta Aerospace (spacecraft) and Hughes Aircraft (imaging radar).

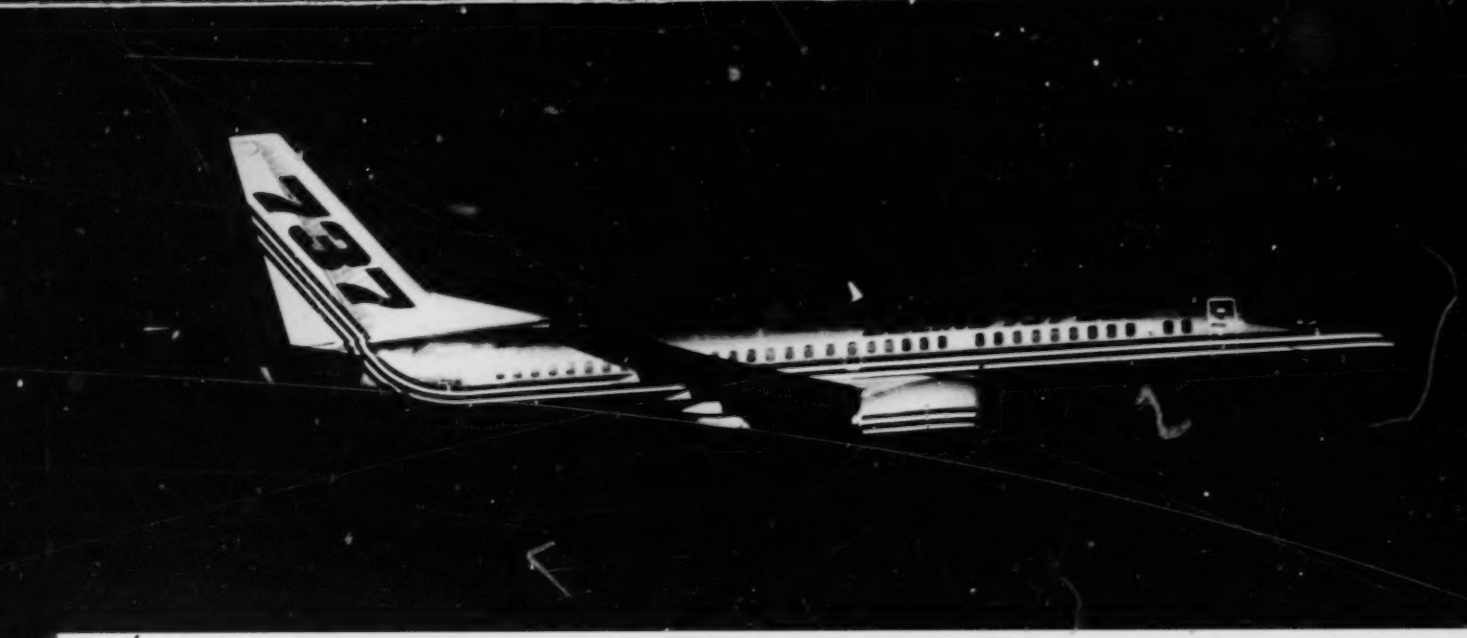
• The Advanced X-ray Astrophysics Facility (AXAF), intended to observe x-ray sources in the universe 100 times weaker than those viewed by predecessor x-ray observatories. In 1984, TRW Inc. and Lockheed Missiles & Space Company were awarded system definition contracts for AXAF, which is targeted for orbital service in the early 1990s.

• The Gamma Ray Observatory, planned for launch in 1988 to study how gamma rays are produced and where they come from.

The military space program continued the rapid growth evidenced in recent years. Although military space details are classified for the most part, the Department of Defense generally was replacing existing communications, weather and intelligence-gathering satellites with more advanced systems, preparing for next year's introduction of the Space Shuttle to military operations from Vandenberg Air Force Base, California, and developing advanced capabilities in space weaponry, missile attack warning, communications security and spacecraft survivability. Among unclassified developments of 1983:

• The Department of Defense launched the ninth and 10th satellites in a Block I test series of the Navstar Global Positioning System for precise location of air, sea and land vehicles. Prime contractor Rockwell International was developing advanced operational versions to replace the test satellites beginning in 1986; target for operation of the complete 18-satellite network is 1988.

• In development by Lockheed Missiles & Space Company was Milstar, a highly survivable satellite that will operate in the extremely high frequency range and provide secure communications to Army, Navy, Marine Corps and Air Force strategic and tactical forces.



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CIVIL AVIATION

New records in passenger traffic, cargo traffic and operating profit, and the first net profit in several years, marked the improving traffic and financial performance of U.S. airlines in 1984. The Air Transport Association reported that the airlines transported about 340 million passengers, up from the previous record of 318 million set in 1983. Final air freight results for the year were expected to top 6.5 billion revenue ton miles of service; the previous high was six billion ton miles in 1983. The volume of mail moving by air was also up in both domestic and international service.

Operating profit was almost $2 billion, surpassing the previous operating profit record of $1.4 billion in 1978. When final results for the year are in, it is expected that the net profit will be between $600 million and $800 million. ATA credited four major areas of favorable economic impact for the airlines' financial performance upturn: an improved economy, declining fuel prices, moderation in labor cost increases and less intensive price wars. These factors, ATA said, will constitute the major influences on the airlines' 1985 performance.

The value of commercial transport aircraft on order or option by U.S. carriers at year-end amounted to about $30 billion, this included orders for 446 aircraft valued at $16 billion and options for an additional 401 transports worth $14 billion.

From the manufacturing standpoint, 1984 was a bad news/good new year. Sales of civil aircraft declined once more, as they had in the two previous years—this time by 23 percent. The good news was that the decline appeared to have bottomed and a production upswing was expected in 1985 and later years.

In the commercial transport manufacturing segment of the industry, sales amounted to $5.7 billion, down from $8 billion in 1983. The industry delivered 185 jetliners, which compares with 262 in the previous year. However, orders for new transports picked up sharply in 1984 and the backlog at year-end was the highest since 1980.

1. First of the new generation Boeing 737-300 transports was delivered in November.
2. Also in November, Delta Air Lines took delivery of the first of 60 Pratt & Whitney-powered Boeing 757s.

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Transports in production included the Boeing 727, 737, 747, 757, and 767, and the McDonnell Douglas MD-80 series and DC-10. At the end of the year's third quarter, Boeing had orders on the books for 358 airplanes; the 737 led the list with 168. McDonnell Douglas had orders for 157 jetliners, all but five of them for the twinjet MD-80 and new variants of that model.

McDonnell Douglas launched a new member of the MD-80 series, the MD-87, a shortened 130-seat version (compared with 155 in the basic MD-80) powered by Pratt & Whitney JT8D-200 engines. Finnair and Austrian Airlines became the first carriers to order the MD-87, deliveries of which will start late in 1987. Another new model in production was the MD-83, also powered by the JT8D 200 Series engines. Scheduled for first deliveries this spring, the MD-83 has the standard fuselage length but increased takeoff weight.

In November, Boeing delivered the first of its new generation 737-300 jetliners, following nine months of certification flight testing. USAir, which had placed orders for 30 of the airplanes, became the first airline to take delivery. The 737-300 is powered by CFM56-3 engines, built by an international company composed of General Electric and the French SNECMA. Also in November, Boeing delivered to Delta Air Lines the first of the 757 family powered by Pratt & Whitney PW2037 engines; Delta had 60 of the 187-seat transports on order.

General aviation aircraft manufacturers delivered fewer aircraft than in 1983 but their dollar value was up by more than 15 percent, due largely to an increase in sales of higher-value business jets. General aviation sales totaled $1.7 billion, compared with $1.5 billion in 1983.

The rotary wing segment of the industry produced 418 helicopters valued at $336 million, up from the previous year's 401 units worth $269 million. Major commercial helicopter types in production included the Sikorsky S-76 and Bell Helicopter Textron Model 222 twin-turbine transports, the 44-passenger Boeing Vertol Model 234 and Bell's new Model 400 TwinRanger, a seven-seater with a four-bladed main rotor made of composite materials. A new manufacuturing program in 1984 was production by Schweizer Aircraft Corporation of the Hughes 300C helicopter under a licensing agreement with Hughes Helicopters. The first Schweizer-built 300C was delivered in June and by year-end the company had delivered 13 of the helicopters.

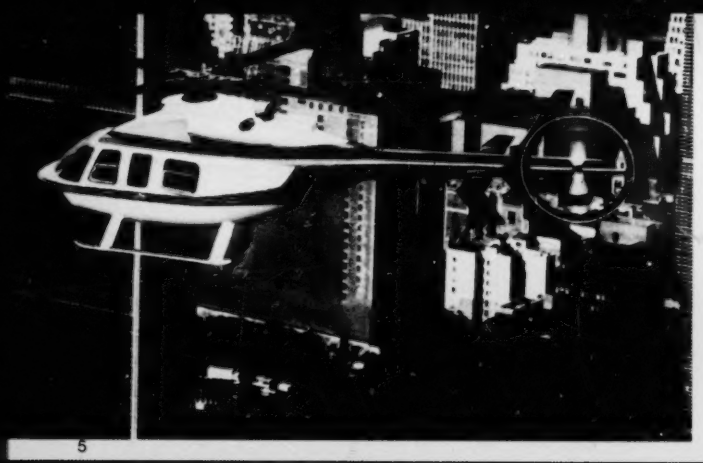
Sikorsky started deliveries on an order from the Peoples Republic of China for 24 S-70C civil versions of the Black Hawk military helicopter, marking the first sales of Sikorsky aircraft to mainland China.

Selected by Canada to develop a Canadian helicopter industry, Bell started construction on a new facility near Montreal and initiated labor hiring. The plant will be used for production of the Model 400.

In civil aviation research, NASA started a new phase of the Sikorsky-built Rotor Systems Research Aircraft (RSRA) program. The RSRA was flown as a fixed-wing airplane with its rotor removed, power supplied by jet engines normally used to test the aircraft as a compound (wing plus rotor) helicopter. These tests were aimed at determining the RSRA's handling qualities in the fixed-wing mode as a preliminary to a joint NASA/Defense Advanced Research Projects Agency X-wing program. One of the two RSRAs was converted to the X-wing configuration for flight testing; the X-wing features a rotor that can be stopped in flight to become, in effect, a fixed airfoil for greater speeds than can be attained with a rotor system.

NASA also continued flight testing of the XV-15 Tilt Rotor Research Aircraft built by Bell Helicopter Textron, developing data toward future use of the tilt-rotor transport in civil operations and also acquiring information to support military development of the JVX tilt-rotor.

NASA signed an agreement with the Navy for flight test of a supersonic oblique wing F-8 fighter, the operational version of which is built by LTV Aerospace and Defense Company. This is a follow-on to an earlier NASA program in which an experimental AD-1 aircraft, fitted with a wing that could be pivoted to various angles up to 60 degrees, was flown in a 38-flight series. The AD-1 was designed to explore—at the low end of the speed



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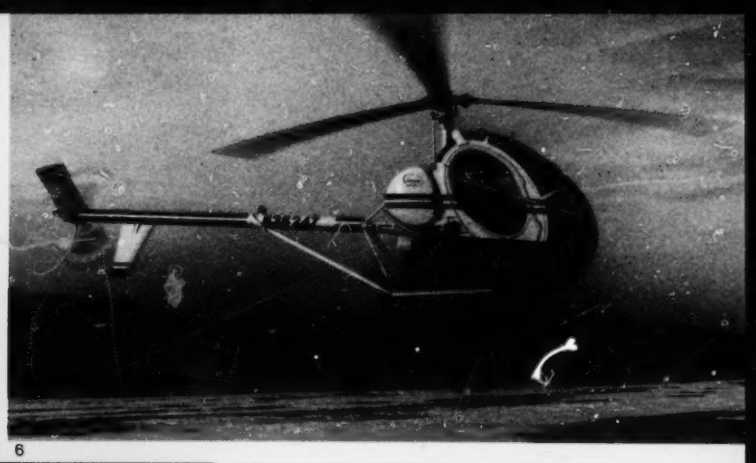

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range—the civil and military potential of the oblique wing concept, which offers potentially greater aerodynamic efficiency at supersonic speeds while retaining good efficiency and flying qualities at lower speeds. The new program will expand on AD-1 results at speeds up to Mach 1.4. NASA planned to award preliminary design contracts in 1985 toward wing fabrication in 1986 and flight tests beginning in 1988.

NASA's Advanced Turboprop Program progressed with selection of Allison Gas Turbine Division of General Motors for design, fabrication and testing of a gear box assembly to drive an advanced propfan. Hamilton Standard division of United Technologies was developing a nine-foot-diameter swept-tip propeller assembly. NASA intends to combine the propeller, gear box and a modification of an existing engine into a turboprop system to be test flown beginning in 1988.

Sikorsky's ACAP (Advanced Composite Airframe Program) helicopter made its initial flight in July and embarked on a 37-hour first phase flight test program. The ACAP became the first all-composite-airframe helicopter to reach flight status. Avtek Corporation's Avtek 400, an all-composite-airframe executive turboprop, made its first flight in September. These developments underlined the trend toward greater use of composite materials, generally lighter but stronger than the metals they replace, in all types of aircraft.

3. In production for first deliveries in 1985 was the McDonnell Douglas MD-83, a standard-length, higher weight version of the MD-80.
4. McDonnell Douglas launched development of a shortened model of the MD-80 series, the MD-87; scheduled for airline service in 1987.
5. Selected to develop a Canadian helicopter industry, Bell Helicopter Textron started construction of a plant in Montreal for production of its Model 400 pictured.
6. June marked delivery of the first Schweizer-built 300C helicopter, being produced under license from Hughes Helicopters.
7. In production was the Boeing Vertol Model 234.
8. Sikorsky's ACAP all-composite-airframe helicopter made its initial flight in July.

8

AEROSPACE REVIEW AND FORECAST 1984/85

Aerospace '84

In 1984, aerospace industry sales increased five percent in inflation-adjusted *real* terms and the real sales level was the industry's highest since 1968. Both export sales and the international aerospace trade balance fell below the previous year's figures. Backlog and profits gained, and employment increased moderately.

Here is a summary, based on preliminary data, of the aerospace year 1984:

Sales. Total industry sales amounted to $83.1 billion, up from $75.8 billion in 1983. In current dollars, the 1984 sales volume was the largest in the industry's history; in real terms, it approached but fell short of the all-time peak year 1968. The industry recorded real increases in the military aircraft, missiles and space categories that more than offset a sharp decline in civil aircraft sales.

Sales of military aircraft increased from $29 billion in 1983 to $33 billion in 1984. Space sales, civil and military combined, continued their dramatic rise to $16.8 billion, which compares with $13.9 billion in 1983. Missile activity, at $11.4 billion, was up $2.3 billion. Civil aircraft sales amounted to $9.8 billion, compared with $12.2 billion in 1983, a 23 percent real drop. Sales of non-aerospace products and services totaled $12.1 billion, up some $500 million in current dollars but almost exactly level with 1983 in real terms.

Backlog. Orders on the industry's books at year-end 1984 totaled $132.5 billion, an all-time high that represents a gain of more than $16 billion during the year. Orders from the U.S. government—$81.4 billion—accounted for more than 61 percent of the total.

International Trade. The strength of the U.S. dollar, delayed recovery for some foreign economies, and increased competitiveness of foreign manufacturers combined to reduce aerospace exports almost seven percent below the 1983 level; the figures were $15 billion in 1984, $16.1 billion in 1983. Aerospace imports rose to $4.7 billion from 1983's $3.4 billion, an increase of 37 percent overall and 53 percent in the civil aircraft category. The aerospace balance of trade was $10.2 billion in 1984, down from $12.6 billion in 1983.

Earnings. The aerospace industry recorded a record profit of $3.6 billion, which compares with $2.8 billion in 1983. Measured as a percentage of sales, the profit rate was 4.3 percent, well below the average of five percent for all U.S. manufacturing corporations.

Plant and Equipment. Aerospace industry expenditures for new plant and equipment increased sharply, from $4.9 billion in 1983 to $6.1 billion in 1984; as a percentage of sales, they increased from 6.5 percent to 7.4 percent. For 1985, projections indicate a further increase to $6.7 billion, but a dip to 6.8 percent when expenditures are measured as a percentage of sales.

Employment. Aerospace employment increased moderately during 1984. The industry work force at year-end numbered 1,242,000, up from 1,171,000 at the end of 1983.

Forecast

AIA estimates indicate that total sales in 1985 will reach $97.9 billion, up 12.5 percent over 1984 in real terms, and that 1985 will become the industry's all-time peak year. The projection assumes continuing increases in industry military and space activities, coupled with a turnaround in the civil aircraft manufacturing sector, where activity has been depressed for several years. Employment is expected to rise to 1,280,000, which would be the highest level since 1969.

Defense. AIA projects that sales of aerospace products to the Department of Defense will top $55 billion in 1985, an increase of more than 16 percent over 1984, with gains expected in all categories—aircraft, engines and parts, missiles and space. The record backlog of orders indicates that defense production activity will continue at high levels over the next two or three years. For the longer term, Congressional concern over budget deficits creates uncertainty as to future levels of defense spending. If public support for the Administration's defense buildup remains strong, AIA anticipates moderate increases in defense spending throughout the Reagan years, which would mean increasing industry activity into the 1990s.

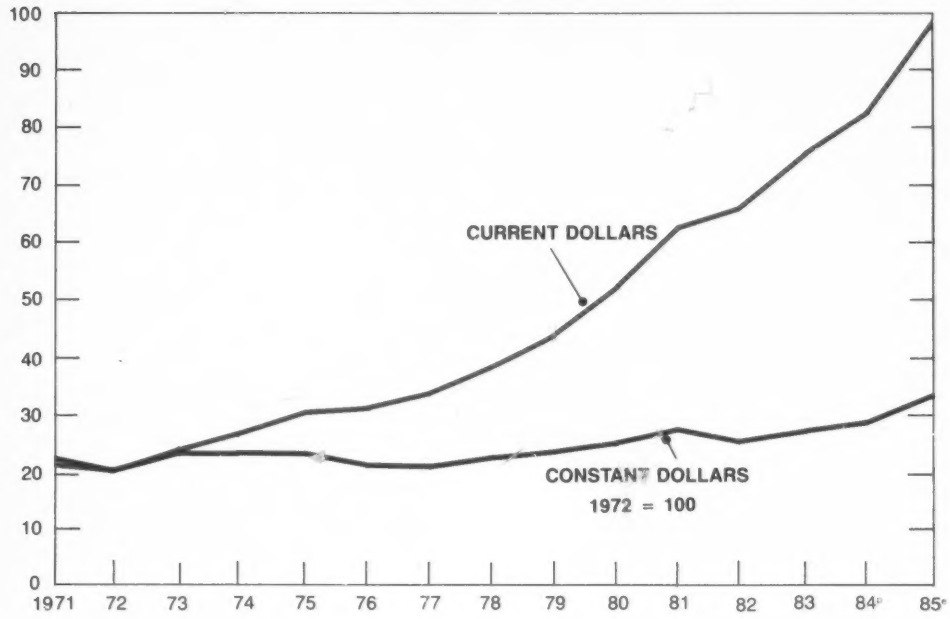
Space. In 1984, sales of space-related equipment were up by more than 20 percent, on top of a 30 percent increase in the previous year. Space continues to be the most rapidly expanding segment of industry business, due largely to the significant growth in defense outlays for space systems. Assuming Congressional reaffirmation of NASA's space station plans and even moderate increases in the defense budget, AIA expects substantial sales growth in the two government-funded areas of space activity. Projections also indicate considerable growth in industry fabrication of commercial space systems, principally communications satellites but also including commercial launch systems, space and ground systems for commercial remote sensing operations, and free-flying platforms for commercial orbital processing experiments. The latter area, space processing aboard the Space Shuttle, the space station or associated platforms, suggests increased activity of an R&D nature for aerospace firms. All in all, with gains indicated in all three areas—military, NASA and commercial—the industry's space workload bids to become an even more significant proportion of total sales in the 1980s and beyond.

Civil Aircraft. Although civil aircraft sales fell sharply in 1984, AIA feels that the sales curve bottomed last year and should start a new ascent. The main reason is the improving financial health of the world's airlines, which has prompted some carriers to resume reequipment plans even though the industry as a whole has not fully recovered from the recent recession. This resulted in a surge of new orders for airline transports in 1984, at a level roughly double that of the previous year; these orders will become deliveries in 1985, 1986 and later years. AIA sees a similar upturn in overall civil aircraft production, including helicopters and general aviation aircraft. The association is projecting an increase of 40 percent—to $13.8 billion—in 1985 civil aviation sales.

For the long term, AIA sees increased transport sales due to the projected growing demand for air transportation and requirements for replacement aircraft. Current market forecasts range from $150 to $250 billion over the next decade; even the lower figure far exceeds the value of all transports delivered over the last *two* decades. Depending on how large a share of this huge market U.S. companies will capture, commercial transport production could—within the next decade—increase to the highest level of all time.

AEROSPACE INDUSTRY SALES

(Billions of Dollars)

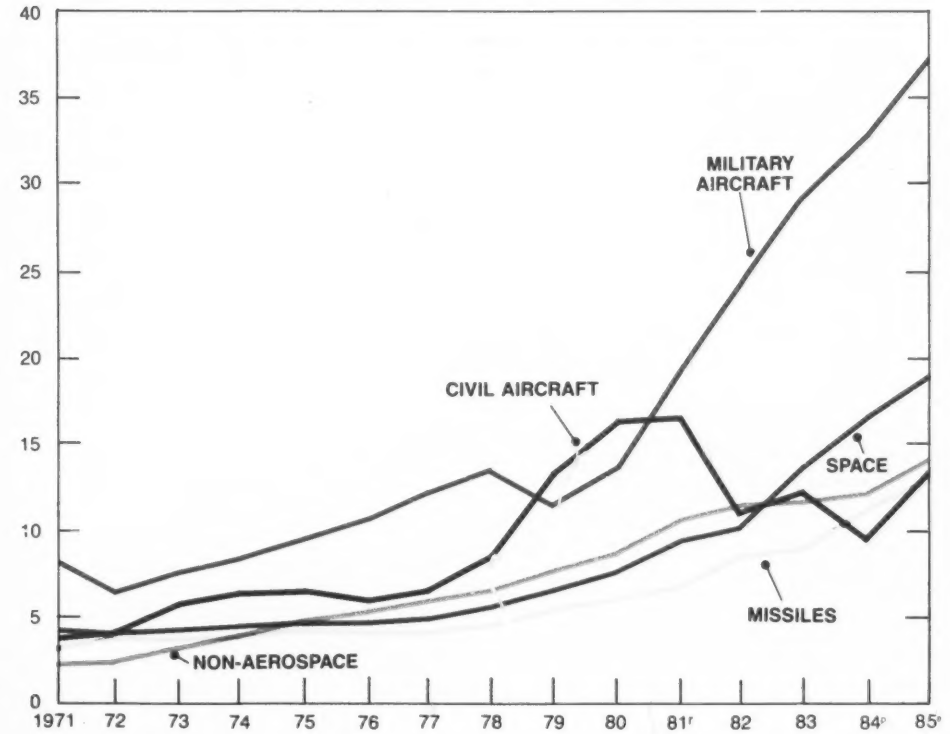


The aerospace industry's 1984 total sales of $83.1 billion included $71 billion in sales of aerospace products and services and $12.1 billion in non-aerospace sales. The Department of Defense predominates in a breakdown of aerospace sales by customer; DoD sales amounted to $47.7 billion, while sales to NASA and other government agencies totaled $6.3 billion. Non-government sales of aerospace products were $17 billion. For 1985, Aerospace Industries Association estimates total sales at $97.9 billion, with $83.7 billion of it—about 85 percent—in sales of aerospace products and services.

Source: Aerospace Industries Association
r Revised
p Preliminary
e Estimate

AEROSPACE INDUSTRY SALES BY PRODUCT GROUP

(Billions of Current Dollars)

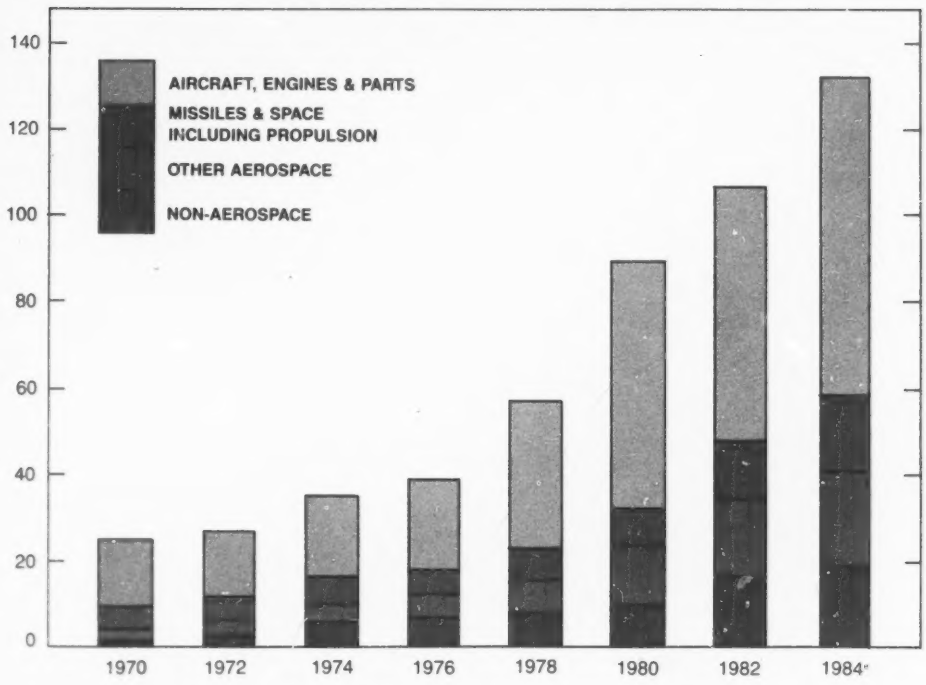


As is customary, production of aircraft represented the largest single element of the 1984 sales volume—more than 51 percent. Sales of military aircraft, at $33 billion, accounted for more than three-quarters of all aircraft sales. Civil aircraft sales, depressed for the past three years, amounted to $9.8 billion. The largest gain in 1984 was in sales of missiles, up 25 percent in current dollars and 19.6 percent in real terms. Space related business increased 21 percent (15.5 percent with adjustment for inflation) and was second only to military aircraft among major sales categories. Non-aerospace sales were approximately level, up slightly in current dollars, down slightly in real terms. For 1985, AIA projects gains in all categories, led by a rebounding 40 percent increase in civil aviation sales, followed by increases of 18 percent in missiles, 17 percent in non-aerospace, 14 percent in space systems and 13 percent in military aircraft.

Source: Aerospace Industries Association
p Preliminary
e Estimate

AEROSPACE INDUSTRY BACKLOG BY PRODUCT GROUP

(December 31, selected years, billions of current dollars)



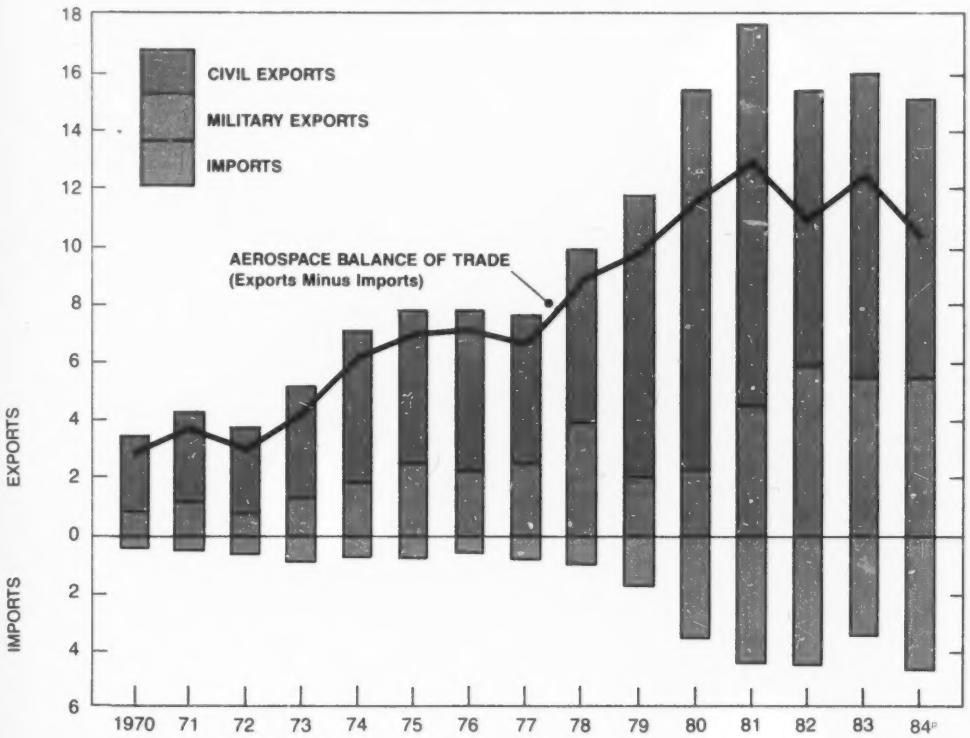
Source: Aerospace Industries Association, based on date from the U.S. Department of Commerce, Bureau of the Census and AIA estimates.

e Estimate

The aerospace industry's backlog of orders at year-end was $132.5 billion, up 14 percent above the $116.3 billion on the books at the end of the previous year. Orders from the U.S. government — $81.4 billion — accounted for more than 61 percent of the total. Orders for aircraft, engines and parts constituted almost 56 percent of the backlog. A breakdown of other backlog shows more than 13 percent in orders for missiles and space systems, about 16 percent in "other aerospace" systems and 15 percent in non-aerospace products and services.

AEROSPACE EXPORTS, IMPORTS AND TRADE BALANCE

(Billions of Current Dollars)



Source: Bureau of the Census.

p Preliminary

The 1984 aerospace export volume declined seven percent to $15 billion, which compares with the previous year's $16.1 billion. Civil exports, including aircraft, engines and parts a-amounted to more than $9.5 billion and military exports totaled more than $5.4 billion. The decline in exports was due to reduced civil sales abroad, down almost $1 billion from 1983; military exports remained at approximately the previous year's level.

Aerospace imports, at $4.7 billion, rose 37 percent to their highest-ever level. The aerospace balance of trade was $10.2 billion; that compares with $12.6 billion in 1983 and the all-time high of $13.1 billion in 1981.

CIVIL AIRCRAFT SHIPMENTS

Calendar Years 1968–1985

	NUMBER OF AIRCRAFT SHIPPED				VALUE (Millions of Dollars)			
Year	TOTAL	Commercial Transport Aircraft[a]	Helicopters	General Aviation	TOTAL	Commercial Transport Aircraft[a]	Helicopters	General Aviation
1968	14,922	702	522	13,698	$ 4,267	$3,789	$ 57	$ 421
1969	13,505	514	534	12,457	3,598	2,939	75	584
1970	8,076	311	482	7,283	3,546	3,158	49	339
1971	8,158	223	469	7,466	2,984	2,594	69	321
1972	10,576	227	575	9,774	3,308	2,660	90	558
1973	14,709	294	770	13,645	4,665	3,718	121	826
1974	15,326	332	828	14,166	5,091	3,993	189	909
1975	15,251	315	864	14,072	5,086	3,779	274	1,033
1976	16,429	222	757	15,450	4,592	3,078	285	1,229
1977	17,913	155	848	16,910	4,451	2,949	251	1,551
1978	18,962	241	904	17,817	6,458	4,308	328	1,822
1979	18,460[r]	376	1,029[r]	17,055	10,644	8,030	403	2,211
1980	13,634	387	1,366	11,881	13,058	9,895	656	2,507
1981	10,916	387	1,072	9,457	13,223	9,706	597	2,920
1982	5,085	232	587	4,266	8,610	6,246	365	1,999
1983	3,354	262	401	2,691	9,739	8,000	269	1,470
1984[(e)]	2,973	185	418	2,370	7,680	5,669	336	1,675
1985[(e)]	3,227	287	540	2,400	11,171	8,735	536	1,900

Source: Aerospace Industries Association, based on company reports, data from the General Aviation Manufacturers Association, and AIA estimates.

a Includes all U.S. manufactured civil jet transport aircraft plus the turboprop-powered Lockheed L-100.

(o) Preliminary.

(e) Estimate.

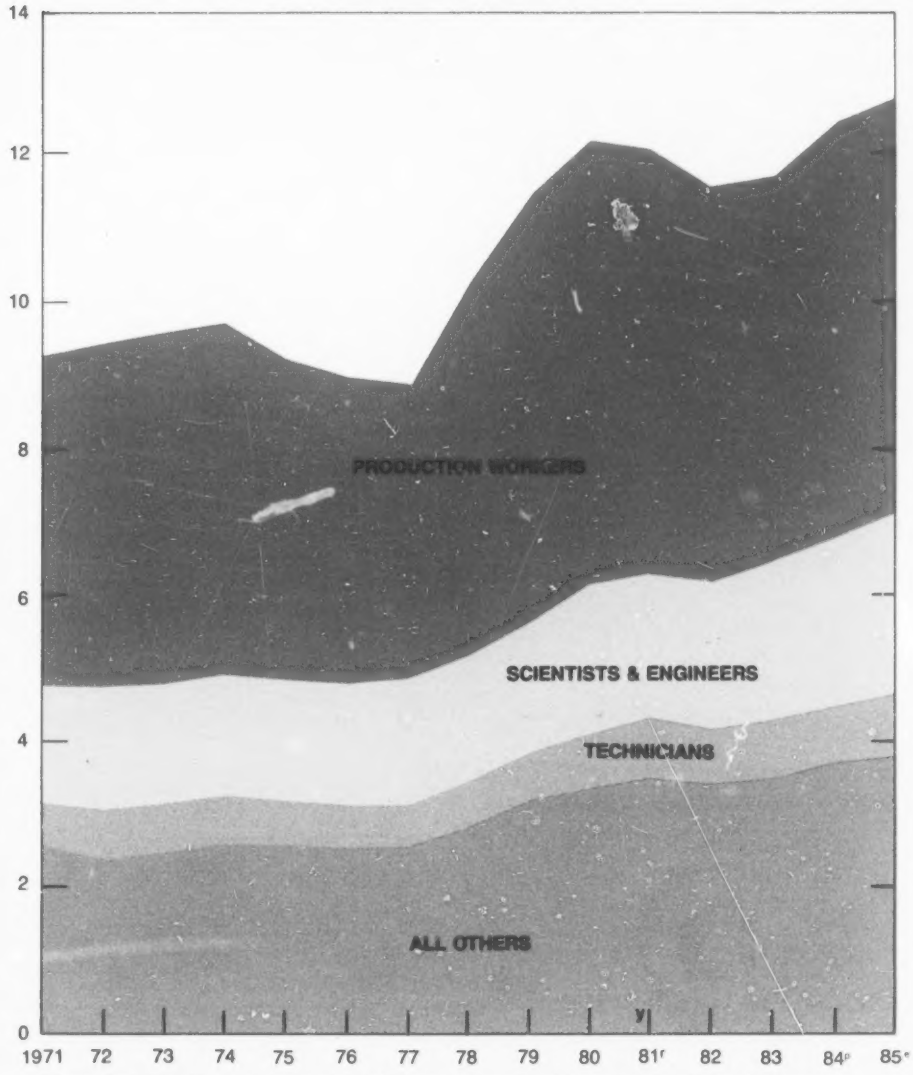
r Revised.

Total shipments of civil aircraft declined in both numbers and dollar value. The industry delivered 2,973 aircraft, down 381 units from 1983 to a level representing less than 16 percent of total shipments in the peak year (1978). Total dollar value was $7.7 billion, some $2 billion lower than in 1983. The $7.7 billion figure is the value of complete aircraft delivered during the year; it differs from the earlier-mentioned civil aircraft sales volume of $9.8 billion in that the latter figure includes the value of spare engines and parts.

Commercial transports accounted for 74 percent of the total value of civil aircraft deliveries. The industry delivered 185 transports (down from 262 in 1983) worth $5.7 billion (down from $8 billion). General aviation shipments dipped slightly to 2,370 units (down from 2,691) but dollar value increased to $1.7 billion (up from $1.5 billion). Helicopter deliveries increased by 17 units to 418; dollar value was $336 million, up from 1983's $269 million. Projections for 1985 show total shipments of 3,227 aircraft worth $11.2 billion, with both dollar value and unit gains expected in all categories.

AEROSPACE EMPLOYMENT

(hundreds of thousands of employees as of December 1971–85)

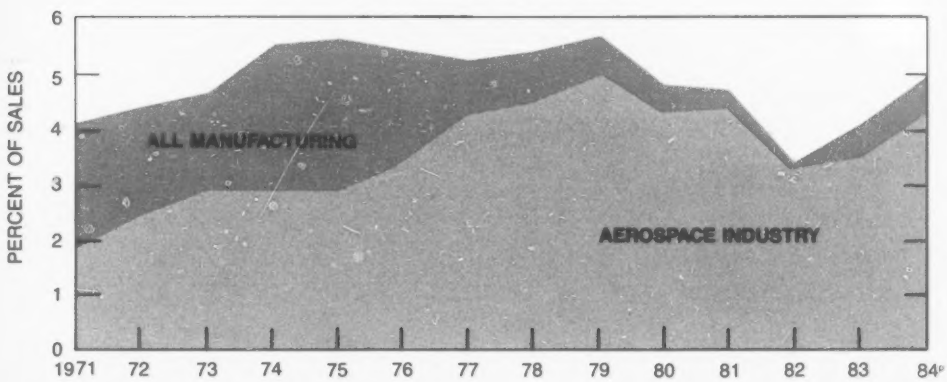


Source: Aerospace Industries Association, based on data from the U.S. Department of Labor, Bureau of Labor Statistics, "Employment and Earnings" and AIA Semi-Annual Survey of Aerospace Industry Employment.

p Preliminary.
e Estimate.

At year-end 1984, the aerospace industry's labor force numbered 1,242,000, up from 1,171,000 at the end of the previous year. The largest increase was in production workers, up 36,000 to 564,000. The number of scientists and engineers increased by 13,000 to 229,000 and employment of technicians was up by 5,000 to 84,000. There was also an increase of 17,000 in the "all others" category, which totaled 365,000 at year-end. For 1985, AIA projects an overall gain of 38,000 to a year-end total of 1,280,000.

NET PROFIT AFTER TAXES



Source: Aerospace Industries Association

r Revised

p Preliminary

The aerospace industry recorded a profit after taxes of $3.6 billion in 1984, up from $2.8 billion in 1983. Measured as a percentage of sales, the profit rate was 4.3 percent, compared with 3.5 percent in the previous year and an average of 4.1 percent for the five-year period 1979-83. The 1984 figure compares with an average profit rate of five percent for all U.S. manufacturing industries.

AIA

MEMBERS

Abex Corporation
Aerojet-General Corporation
Aeronca, Inc.
Allied Corporation
Aluminum Company of America
Avco Corporation
The Boeing Company
Colt Industries Inc.
  Chandler Evans Inc.
  Menasco Inc.
  Delevan Corporation
Criton Technologies
E-Systems, Inc.
Ex-Cell-O Corporation
FMC Corporation
The Garrett Corporation
Gates Learjet Corporation
General Dynamics Corporation
General Electric Company
General Motors Corporation
  Allison Gas Turbine Division
The BF Goodrich Company
Goodyear Aerospace Corporation
Grumman Corporation
Hercules Incorporated
Honeywell Inc.
Hughes Aircraft Company
IBM Corporation
  Federal Systems Division
ITT Defense Space Group
  ITT Aerospace/Optical Division
  ITT Avionics Division
  ITT Defense Communications Division
  ITT Federal Electric Corporation
  ITT Gilfillan
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Lear Siegler, Inc.
Lockheed Corporation
LTV Aerospace and Defense Company
The Marquardt Company
Martin Marietta Aerospace
McDonnell Douglas Corporation
Morton Thiokol, Inc.
Northrop Corporation
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Pneumo Corporation
  Cleveland Pneumatic Company
  National Water Lift Company
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The Singer Company
Sperry Corporation
Sundstrand Corporation
Teledyne CAE
Textron Inc.
  Bell Aerospace Textron
  Bell Helicopter Textron
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- SDI—WHAT, HOW, WHY
- 1986: A BIG YEAR IN SPACE

Notable views of notable people on aerospace matters...

aerospace perspectives

Senator Barry Goldwater, *Arizona, chairman of the Senate Armed Services Committee, writing in the Des Moines Register:*

"The defense budget is not sacrosanct. Some reductions will doubtless be necessary this year in light of the federal deficit. But given how far we've come in improving our defenses, how those reductions are applied is terribly important. Superficial,implusive schemes like Senator (Charles) Grassley's defense freeze, are far better suited to bumper stickers than the realities of the dangerous world in which we live. When reductions are made, it is vital they be based on thorough analysis and guided by the best professional judgment available. Our own taxes and our children's security depend on it."

Edward L. Rowny, *special advisor to the President and to the Secetary of State on arms control matters, writing in the New York Times:*

"The Soviet Union seems determined to prevent American research on strategic defense, research that the Russians themselves have long been conducting . . .

"One often hears the question 'Why should Moscow reduce its offensive weapons while we're pushing defense research?' First, we are not alone in efforts to explore the feasibility of ground- and space-based defense against ballistic missile attack. Long before President Reagan's speech in 1983 outlining the Strategic Defense Initiative, the Soviet Union was engaged in a large-scale defense research program.

"Further, the Russians have been violating the anti-ballistic missile treaty. Given the pattern of their many activities in strategic defense, we are concerned that they may be establishing a base for a nationwide ballistic missile defense capability. Such a move, combined with an erosion in the offensive balance, would have severe consequences.

"Finally, as both sides have acknowledged, research is not verifiable and hence not negotiable. But the Russians seem determined to continue their own research while trying to stop ours. The freeze they propose on offensive forces would simply codify existing Soviet advantages."

Robert E. Hunter, *director of European studies at the Georgetown University Center for Strategic and International Studies, writing on "The Relevance of American Power" in the SAIS Review:*

"It has been increasingly evident for more than a decade that the world of military power and security also coexists with the world of economic power and security. This second world demands 'equal time' to a degree unparalleled in the postwar world. In absolute terms, of course, U.S. economic power has increased steadily since World War II. But so has that of other nations, so that our margin of advantage has diminished relatively; we have gone from being a giant among pygmies to being first among near-equals. . .

"Changes in the global economy also have long-term implications for U.S. power and influence within the Western alliance. For the early part of the postwar period, there was no inherent economic contradiction within the Western alliance, because rebuilding Western Europe was an essential part of security and a net addition to U.S. power. There was also a common interest in one another's prosperity and in the functioning of the global economy. Yet about the time of the collapse of the Bretton Woods system in 1971—and not coincidentally—economic competition across the Atlantic began seriously to rival the motive of common interest. Today, in fact, differences over economics have become one of the central systemic trends in the Western alliance. Such differences could weaken it economically and politically and, as a consequence, weaken U.S. power as represented by Western solidarity."

Harry J. Gray, *chairman and chief executive officer of United Technologies Corporation, in the keynote speech to the National Conference of the National Security Industrial Association in Washington, D.C.:*

"In the case of critical military technology, we've got to be ultra-vigilant to keep vital knowledge from the wrong hands. In relationships with partners in allied countries, we have to work closely with them and their governments to assure tight-fisted security. We have to be more restrictive in sharing technology with some allies than with others, depending on their policies on selling weapons to other countries.

"Clearly, our national interests must come first at all times. We must be alert to government policies, however, that place unnecessary and excessive restrictions on technology. Unrealistic barriers to technology exports handcuff America economically and degrade us in the eyes of our friends and allies.

"We must be certain that any technologies we withhold for our exclusive use are critical to our interests and are uniquely ours. It is folly to deny a friendly country technology it can get elsewhere . . .

"Government legislation and regulation must take into account these realities. Unnecessary restrictions on knowledge, exports and international partnerships are damaging to the U.S. in the long run. They undermine our economic and security interests. They impair technological advancement. They undercut job creation. They damage relations with other countries that share our economic interests as well as the burden of collective security . . . We need legislation to provide the kind of effective controls that don't generate counterproductive consequences."

Verne Orr, *Secretary of the Air Force, in an address to the Institute for Contemporary Studies in Los Angeles, California:*

"If Ronald Reagan gets all he's asked for Fiscal Year 1986, your defense budget will amount to about 6.3 percent of the Gross National Product. Historically, that's not high. Under President Kennedy, we spent eight percent of our GNP for defense and under President Eisenhower we spent around 10 to 11 percent—almost double the percentage of defense spending that has suddenly become 'a burden we can't bear.' "

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By Brigadier General Robert R. Rankine, Jr., USAF

10 1986: A BIG YEAR IN SPACE
By James J. Haggerty

16 NEW GOALS FOR AERONAUTICAL R&D

On the cover: The artist's concept shows an Earth-generated laser beam being reflected toward a high-altitude target by a space-based mirror. This is one of a number of ballistic missile defense concepts being explored in the Strategic Defense Initiative research program *(see page 2).*

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems.

Foster understanding of the aerospace industry's responsibilities in the space exploration program.

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade.

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

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A Perspective on the Defense Industry

BY KARL G. HARR, JR.
President, Aerospace Industries Association

The following is a reprint of an article by Dr. Harr in "The Debate" section of USA Today *in April:*

Defense and space business is paid for by the taxpayer, involves vital national security interests, and is controlled by the government customer. Thus, defense is the "people's business" and both the media and the political establishment justly feel they have a right and a duty to monitor it closely.

It is important to place in perspective the essential characteristics of the defense industry and the procurement process under which it operates.

The defense industry is large, with annual sales well over $100 billion. It is enormously complicated, charged not only with producing but *inventing* complex systems at the cutting edge of technology. Its high-tech products must meet extraordinary standards of performance and reliability.

It is free enterprise that must serve two masters, the government customer and the corporate stockholders. It is perhaps the most closely audited and scrutinized industry in the history of our nation.

But, as a peacetime entity, it is a young industry, born in the wake of World War II to counter a Soviet threat and publicly supported, in the years since, only as long as and to the extent that such a threat was perceived.

There were no precedents to guide the creation of a large peacetime defense establishment, so development of the procurement process has been largely a matter of experimentation, trial and error, lesson-learning in a constantly changing defense environment.

The government and industry have spent 30 years working out the necessarily complicated rules of the game. That they have substantially done so is evidenced by the exceptional performance of the industry.

It has produced—and continues to produce—the world's finest weapon systems. It has made tremendous advances in weapons capabilities, reliability, and performance as well as in deliveries within cost and schedule.

In addition, industry-developed equipment has enabled the USA to lead the world in space exploration and exploitation and to dominate world-wide sales of airline transports. Much government/industry effort has gone into the system that made these considerable achievements possible.

Admittedly, the system has on occasion come up short: a product is delivered late, costs too much, or fails to meet performance standards.

Industry can take its share of the blame. So can the Pentagon. So can the Congress. Such irregularities must be and are being corrected.

But widely publicized abuses are anomalies, not the norm. They must not be allowed to distract our attention from the main task of ensuring the efficient functioning of a process so vital to the nation's security and economy.

THE WHY, WHAT, AND HOW OF THE STRATEGIC DEFENSE INITIATIVE

By Brigadier General Robert R. Rankine, Jr., USAF

General Rankine holds three separate jobs within the Air Force, all of them related to the Strategic Defense Initiative (SDI). He is special assistant for SDI to the Deputy Chief of Staff, Research, Development and Acquisition; special assistant, SDI, to the Vice Commander, Air Force Systems Command; and he is responsible, at USAF headquarters, for the Air Force's science and technology program. In recent assignments prior to taking up his present duties, he served in the Office of the Under Secretary of Defense for Research and Engineering as assistant for directed energy weapons and SDI planner, and as Deputy Director of the Strategic Defense Initiative Organization. This article is based on a speech to the American Institute of Aeronautics and Astronautics.

In his March 1983 defense policy speech, President Reagan discussed his continued support for strategic offensive modernization and arms control efforts. He also challenged the scientific community to determine the feasibility of developing systems capable of destroying ballistic missiles in flight, thus providing an alternative to sole reliance on offensive nuclear retaliation as the basis for strategic deterrence, and leading to the ultimate goal of eliminating the threat of ballistic missiles.

Immediately following that speech, the President directed that two studies be accomplished to investigate the policy and the technology implications of an effective ballistic missile defense system. From these two studies emerged the basis for a long-range research program. In October 1984, the Congress appropriated funds for the Strategic Defense Initiative, financing the new hope for the future, first expressed by the President less than nineteen months earlier.

To best understand the scope and breadth of this initiative, I will answer three questions:

First, **why?**—which will address the strategy and policy implications of an effective ballistic missile defense.

Second, **what?**—which will describe the scope and priorities of the research program underway to determine technical feasibility.

And lastly, **how?**—which will describe the procedures we have established to centrally plan and control the program, yet decentrally execute the technology efforts.

In the long term, we have confidence that SDI will be a crucial means by which both the U.S. and the Soviet Union can safely agree to very deep reductions and eventually even the elimination of ballistic missiles and the nuclear weapons they carry. This does not represent a shift from the basic deterrent strategy of the U.S., but represents a new means for enhancing deterrence. That policy, in effect since the beginning of the nuclear era, has not changed in its fundamentals, but our ability to deter has hinged upon differing military capabilities, ranging from a balanced nuclear bomber and air defense capability in the fifties to almost total reliance on the threat of retaliation in the eighties. The shifts in the basis for deterrence have been forced by the development of various nuclear delivery systems and not by fundamental changes in policy.

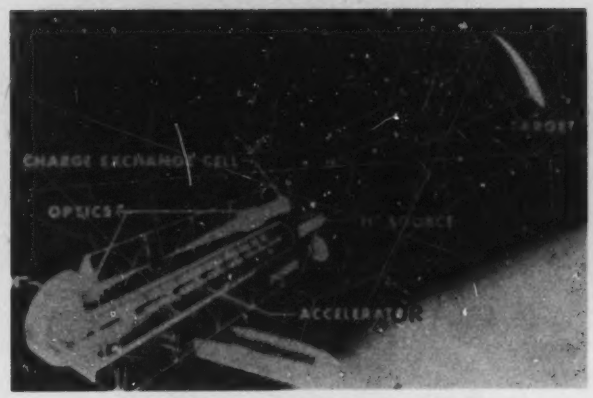
The emergence of nuclear tipped ballistic missiles in the late fifties and sixties changed the timing of nuclear warfare and thus reduced the importance—in the view of many U.S. leaders—of the need for air defenses. Because ballistic missiles are fast and unrecallable and are becoming increasingly accurate, they potentially are the most destabilizing of the currently deployed systems—particularly the ICBMs which may be tar-

This overview of the Strategic Defense Initiative research plan illustrates the four-layered defense system contemplated: attacking ballistic missiles in their boost and post-boost phases, during midcourse flight and in the terminal portion of their trajectories as they descend into the atmosphere.

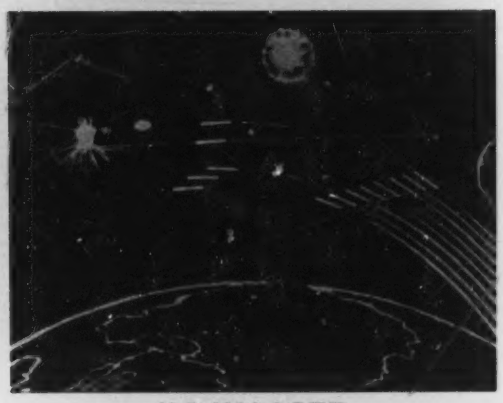
Laser and particle beam systems are among the major candidates for directed energy weapon (DEW) systems, which attack ballistic missiles at or near the speed of light. Lasers are designed to kill by burning a hole in the target vehicle; particle beams penetrate the target's interior to destroy electronic and other internal components.

SPACE BASED LASER

GROUND BASED LASER



NEUTRAL PARTICLE BEAM



X-RAY LASER

An example of a directed energy weapon is the space-based laser system, which offers the opportunity to intercept ballistic missiles in the boost phase, before they can deploy their warheads and decoys. Since laser light penetrates the atmosphere, this type of system may also have potential in defense against airbreathing missiles or aircraft.

geted against each other. Therefore, a ballistic missile defense capability has the potential of increasing deterrence and adding to stability, by increasing substantially the uncertainties in the success of nuclear attack by an enemy, thoroughly confounding his targeting strategy, thus significantly reducing or eliminating the utility of preemptive attack. The system need not be perfect to accomplish this objective, but must meet three important criteria:

- First, it must be effective against the systems and countermeasures that exist or could be deployed.
- Second, it must be sufficiently survivable that it would not encourage an attack on the system itself by either enemy defensive or offensive systems. If it were not survivable, then it might invite a defense suppression attack as a prelude to an offensive attack, thereby decreasing rather than increasing crisis stability.
- Third, in addition to being effective and survivable, defenses must be able to be expanded to maintain effectiveness at lower cost than any proliferation or countermeasure attempts to overcome them. If that were not the case, the existence of defenses would encourage rather than discourage proliferation. Providing for cost-effective and survivable defense is the key challenge to the Strategic Defense Initiative technology program and illustrates the need for research before an informed decision to begin system development is possible.

In the late sixties and early seventies, the United States had done developmental work on an anti-ballistic missile system known as Safeguard. That system, which was deployed in the mid-1970s, was dismantled shortly thereafter, due in part to the fact that it could not maintain effectiveness against proliferation. The U.S. also hoped that not deploying U.S. defenses permitted by the ABM treaty would encourage the Soviet Union not to build more ballistic missiles. It did not. Not only did the Soviets continue to build ballistic missiles, they also relentlessly pursued technology for defending against ballistic missiles.

An example of this was shown in the U.S. Department of Defense publication *Soviet Military Power 1984*, which described a directed energy R&D site at Sary Shagan in the central Soviet Union that not only could provide an antisatellite capability today, but possibly a prototype for an ABM system to be deployed in the future. The Soviets have currently the only operational ballistic missile defense, which is located around Moscow. The system is for terminal defense and similar in many ways to the Safeguard system that we had deployed in the early 1970s. The Soviets are presently modernizing that Moscow system and have developed a rapidly deployable ABM system which has potential for deployment as a nationwide ABM system.

Of even greater concern however, the Soviets have been pursuing for many years extensive development of technologies which have potential for advanced ballistic missile defense applications. Whereas the United States has been developing basic laser technology, the Soviet Union is exploring many laser technologies. In the particle beam area, the most advanced U.S. technology is derived from Soviet research reported in their technical literature several years ago.

The Strategic Defense Initiative program thus provides us a hedge against what might otherwise be a Soviet technical surprise. A unilateral Soviet deployment of such advanced defenses, in conjunction with its offensive deployments and its air and civil defense efforts, could result in a significant change in Soviet military capability and could adversely affect the security of the United States and its allies.

Some of the opponents of the Strategic Defense Initiative have argued that the research and technology program currently under way is inconsistent with the ABM treaty and conflicts with arms control in general. Quite to the contrary, the initiative is totally consistent with current U.S. ABM treaty obligations. The initiative contemplates only research and experimentation on a broad range of defensive technologies to provide the basis for a decision in the future whether or not to develop systems which would provide an effective ballistic missile defense capability.

As we look toward the future, effec-

tive defenses have the potential of decreasing the value of ballistic missiles as instruments of national strategy, thus increasing the likelihood of negotiating reductions in those ballistic missiles. Negotiated reductions in offensive forces, in turn, will enhance the effectiveness of the defenses; we have created a defensive spiral in which both parties would be more willing to negotiate further reductions. Thus defenses couple synergistically with arms control leading to attainment of the ultimate goal stated by the President: to eliminate all threats posed by nuclear ballistic missiles.

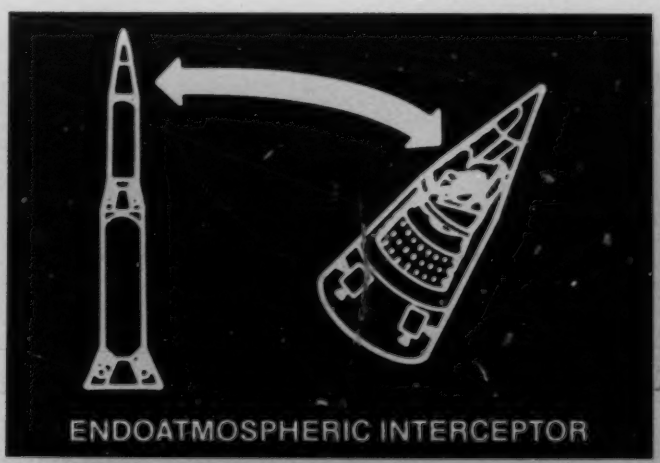
An important aspect of the entire initiative is the fact that the United States is in no way decreasing its commitment to the protection of its allies but, in fact, is examining technologies for defense not only against ballistic missiles that can hit the United States, but against shorter range ballistic missiles that can strike our allies. We are consulting closely with our allies.

The emphasis in the Strategic Defense Initiative on defending against ballistic missiles is due to their potential to increase instabilities. But while the slower moving systems, such as cruise missiles and bombers, are less threatening in this regard, there are separate efforts under way in the services to examine the technologies required to defend against these weapon systems as well.

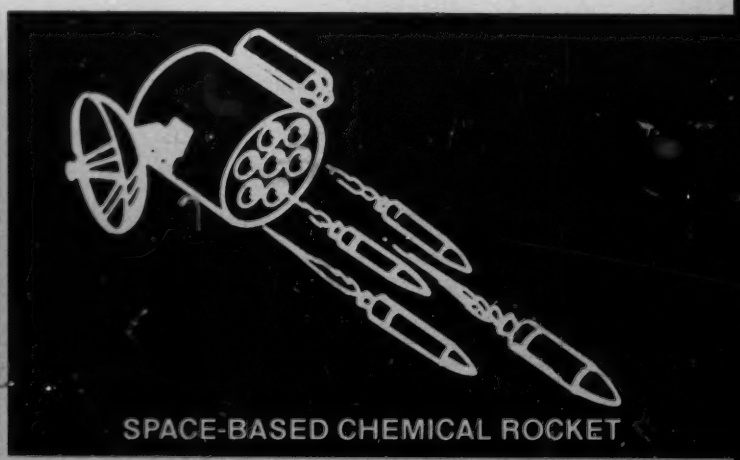
Having described the rationale for the program, I will now describe its technical scope and what has changed over the last 10 years that has made defense against ballistic missiles both more realizable and more effective. To do this, it is important to understand the flight path of a ballistic missile and the various regimes in which ballistic missiles can be attacked. It starts in the boost phase, in which the ballistic missile, being thrust by a large chemical rocket, slowly rises from the face of the Earth enroute to its targets. This phase can be characterized by an intensely bright plume which provides a very large characteristic infrared signature. In this phase, the ballistic missile still has all its warheads attached. Attack in this phase could provide large multiplier effects and would thus provide maximum leverage from a defensive point of view.

In the next phase, post-boost or the bus deployment phase, warheads and penetration aids are deployed in such a way as to attempt to confuse the defenses. This phase is followed by the longest phase, the mid-course phase. The warheads and penetration aids coast on a ballistic trajectory from minutes to tens of minutes on the way to their target. In the last phase—the terminal phase—the warheads and the decoys re-enter the atmosphere. Discrimination

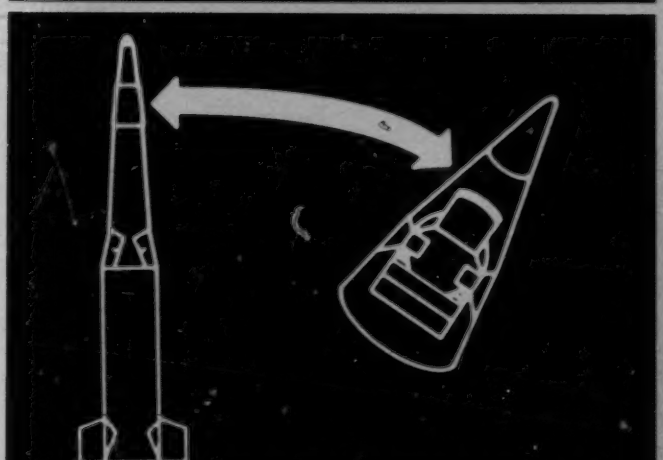
The SDI program involves research on four kinds of kinetic energy weapons, or "smart bullets," each equipped with a small computer and a lightweight sensor: the endoatmospheric interceptor, intended to hit an incoming missile in the terminal phase of its trajectory; the exoatmospheric interceptor, designed for intercept outside the atmosphere in the missile's midcourse phase; small chemical rockets, emplaced on space-based "pods," for intercept in the boost and midcourse phases; and the hypervelocity weapon, also intended for boost/midcourse intercept.



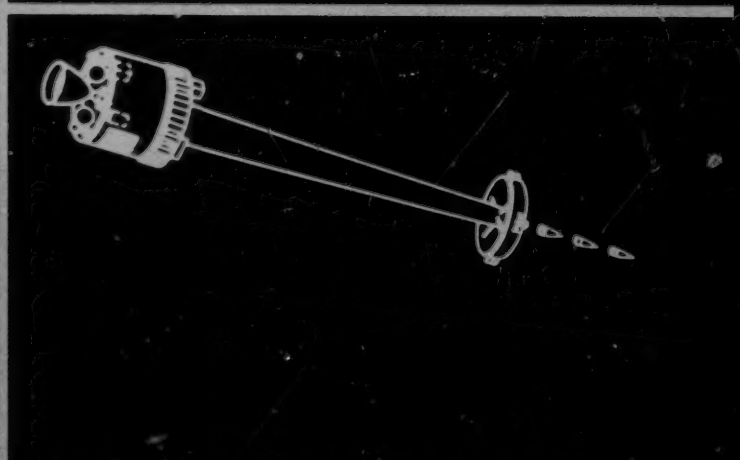
ENDOATMOSPHERIC INTERCEPTOR



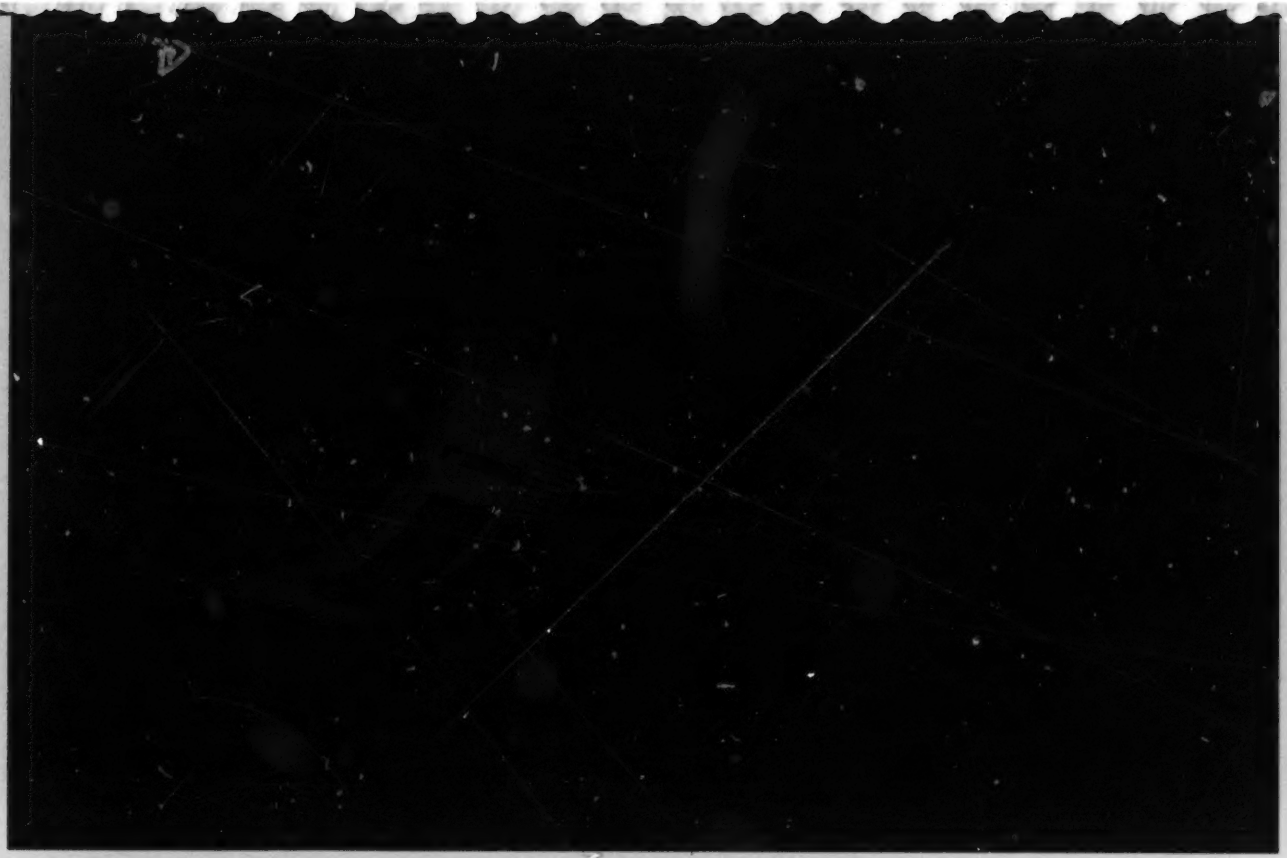
SPACE-BASED CHEMICAL ROCKET



EXOATMOSPHERIC INTERCEPTOR



HYPERVELOCITY LAUNCHER



Among kinetic energy weapon systems being investigated is the space-based hypervelocity launcher, or rail gun, which employs electrical forces rather than chemical propellants to fire "smart" projectiles. The electric gun may be able to generate projectile velocities of more than 20 miles a second, compared with five miles a second for chemical rockets.

is facilitated in this phase by the differing re-entry dynamics and signatures of the warheads and decoys.

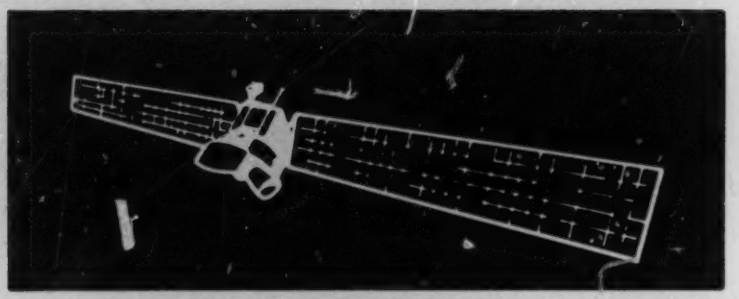
Attacking ballistic missiles in all four of these phases is what is known as a layered defense system. This is a defense-in-depth approach that is not new to the military. For example, it is similar in concept to the approach used by the U.S. Navy to protect a carrier task force. We have the F-14 Tomcat attacking aggressors at long range using the Phoenix missile system; at shorter ranges, using Sparrow and Sidewinder missiles; then followed up by surface-to-air missiles from the support vessels and finally by the Phalanx gun system. Layered defenses relieve the effectiveness requirements on each individual layer and are more resistant to countermeasures.

Certain functions need to be accomplished in each of these four phases for ballistic missiles to be effectively attacked; first, detection, acquisition, discrimination and kill assessment; second, pointing and tracking; third, interception and destruction, and fourth, battle management. The scope of the Strategic Defense Initiative program can be discerned by identifying weapon system concepts for each function in each phase. The collection of technologies that will permit the realization of these concepts defines the technical scope of the program. As an example—in the boost phase—the requirements for detection, acquisition, discrimination and kill assessment could be accomplished by taking advantage of the very bright signature of the booster itself. Space-based infrared sensors could detect and track the booster and thus handoff to a boost phase interception and destruction capability which would employ either directed energy or kinetic energy. The technologies which support such a concept include focal plane arrays, light-weight optics and signal processing for space applications; programs in each of these technical areas are now being pursued under the central management of the Strategic Defense Initiative program. All of these key technologies were being pursued previously; hence, the Strategic Defense Initiative is not a new program, but an entirely new focus for a collection of relevant programs.

For better appreciation of the scope of the program, let me describe some notional architectures for the sensors and weapons that might fulfill the functional requirements of a multi-layered defense.

In the sensor area, we are looking at five interleaved system concepts—first, a boost-phase detection and tracking system which would detect launches of ballistic missiles. In the mid-course area, we perceive the need for a "birth-to-death" tracking and fire control system to provide the tracking of the reentry vehicles from deployment to reentry. Also in the mid-course, we see the need for a laser or radar system to image the post-boost vehicle to observe reentry vehicle and decoy deployment and thus discriminate between the two. In the terminal phase, two systems are currently envisioned, one an airborne optical adjunct which would provide for long-range infrared tracking and discrimination of the reentry vehicles and decoys. And lastly, a ground-based imaging radar which would provide endoatmospheric discrimination of reentry vehicles and decoys.

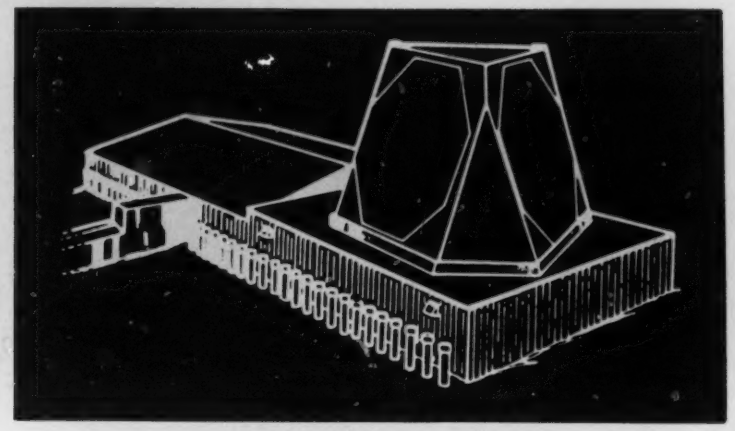
In the kinetic energy weapons area, both ground-based and space-based assets would provide for attack of ballistic missiles in all phases. In the boost-phase, space-based projectiles propelled by chemical rockets or electromagnetic launcher systems would provide a capability of attacking the booster while it is still under power. These same systems would also be capable of attacking post-



SPACE SURVEILLANCE

The SDI Sensors Program is organized into two parts: technology development for new sensors, imaging techniques and associated data processors that will aid in discriminating decoys from warheads; and experimental demonstrations to validate new technologies and provide confidence that full scale development can be initiated.

AIRBORNE OPTICAL SENSOR



TERMINAL RADAR

boost vehicles and reentry vehicles during midcourse flight. In the terminal and late mid-course area, ground-based interceptors would provide a non-nuclear hit-to-kill capability to destroy the reentry vehicles on a one-to-one basis.

Last June, the homing overlay experiment (HOE) conclusively demonstrated the technology of hit-to-kill intercept of reentry vehicles. Some new technology breakthroughs have recently occurred in the hypervelocity launcher area. We have been able to accelerate projectiles from a repetitively fired electromagnetic railgun launcher up to several kilometers per second. In addition, preprogrammed maneuvering projectiles have functioned after sustaining accelerations in excess of 50,000 Gs.

Directed energy weapons are being investigated primarily to attack ballistic missiles in either the boost or post-boost phase. Several options currently exist. Chemically powered space-based lasers might provide long range, speed-of-light intercept and kill of both boosters and post-boost vehicles. Alternatively, ground-based excimer or free electron lasers could bounce their energy off space-based mirrors and thus be able to attack a large number of boosters without the need to put the laser device in space. Neutral particle beams can penetrate deeply into the ballistic missiles, causing catastrophic damage to internal components. Recent work on the Navy's Mid-Infrared Advanced Chemical Laser (MIRACL) has demonstrated not only the highest power, but now also the highest brightness of any laser in the free world. This laser, at the White Sands Missile Range, will be a work horse for the Strategic Defense Initiative, allowing us to determine by actual testing the trade-offs between booster hardening and laser brightness.

Not everything within the broad technical scope of the Strategic Defense Initiative is equal in priority. Five priority technology areas can be defined which provide the keys to an effective defense. First is the definition of weapon concepts for boost-phase and post-boost vehicle intercept. Directed energy weapons such as lasers and particle beams have the promise to provide for long-range intercept of the booster and the post-boost vehicle at or near the speed of light. Kinetic energy projectiles propelled to hypervelocity by chemical propellants or electro-magnetic force also offer potential for such early intercepts. Concurrent with the pursuit of technologies that will make such weapons possible is the definition of the lethality required, not only against currently deployed Soviet ballistic missiles, but also against new missiles built to incorporate countermeasures intended to overcome the effectiveness of these new weapons.

In the mid-course area described earlier, the key to cost-effective defense is discrimination of reentry vehicles from the decoys. If discrimination can be accomplished with sufficiently high confidence, mid-course intercept can be obtained with reasonable numbers of interceptors. By simultaneously advancing technology to reduce the cost of the mid-course interceptors, one can trade off the effectiveness of the discrimination with the cost of attacking more expensive decoys in addition to true reentry vehicles.

Survivability of space-base defense assets is a key to the program. Since these systems must be sufficiently survivable to preclude a pre-emptive attack upon them, major emphasis in the Strategic Defense Initiative program will be to develop survivability measures for the space-based assets to include such things as electronic countermeasures, self-defense, decoys and hardening. However, we are not only looking at the technology to enhance the survivability

of single satellites, but are also exploring the full range of tactics to provide for overall mission accomplishment without the dependency on any one satellite. Tactics of this kind include such things as escort defense, orbit selection, proliferation and maneuver.

The last, and not the least, most important priority technology is in the area of battle management. In the past, the development of high-speed computational capability for the real-time battle management of such a system would have precluded the development and deployment of such an effective layered defense. Today's computer processing capabilities, which are growing by an order of magnitude every three to four years, promise to provide the technology sufficient to support such a system by the turn of the century. Of greater concern, though, is the issue of software preparation and testing. We currently do not have the capability to build and validate the software necessary in a timely manner. Hence, research on "software development tools"—that is, computer programs that can write and test new computer programs—are receiving high priority attention.

With the scope and the priorities of the Strategic Defense Initiative research program thus defined, let me turn now to the question of how the program is being executed. The Congress appropriated $1.6 billion for the Strategic Defense Initiative for Fiscal Year 1985—$1.4 billion for the Department of Defense and $200 million for the Department of Energy. Although this was only 80 percent of what the President had requested, it has nevertheless permitted a focused, centrally-managed beginning for the Strategic Defense Initiative. We believe that the central management of those funds by General Abrahamson's Strategic Defense Initiative Organization (SDIO) has introduced economies and efficiencies which enable us to get more for that money than if the pieces were pursued separately.

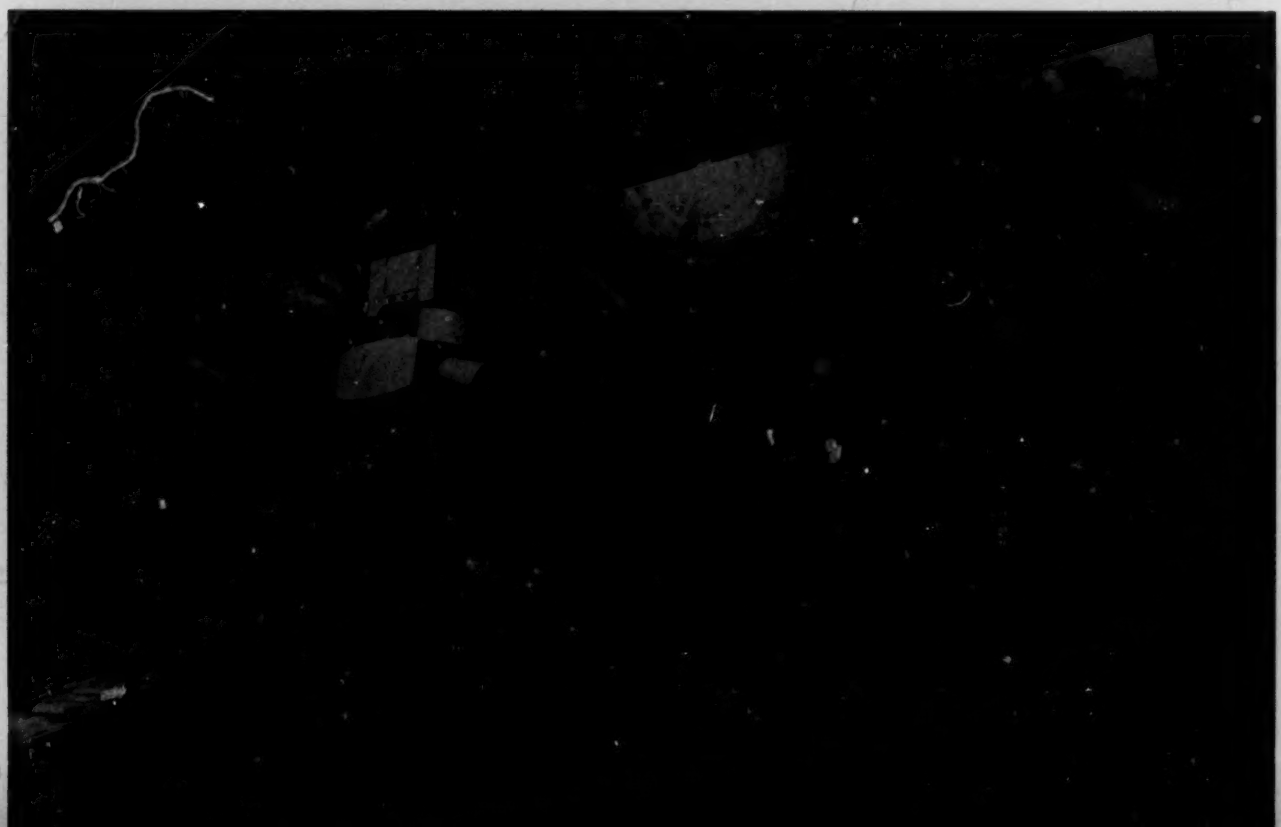
The overall management of the program is characterized by centralized planning and control by the Strategic Defense Initiative Organization with decentalized execution by the Army, Air Force, Navy, DARPA, Defense Nuclear Agency and the Department of Energy.

In FY 85, the two largest executors are the Army and Air Force, with 40 and 35 percent respectively, of the DoD portion of the program. The Army and the Air Force were able to undertake such large portions of work in Fiscal Year 1985 because the work had actually begun in previous years. That is, the Strategic Defense Initiative provided a new context and focus for the Army's prior work on ballisitic missile terminal defense and the Air Force's prior work on space surveillance and space defense. For example, the Air Force was developing technology for detecting and tracking satellites using long-wavelength infrared space-based sensors. This basic technology, with improvements in sensitivity and resolution, provides the basis for reentry vehicle tracking.

Based upon the $3.7 billion budget request for the DoD part of the program submitted to Congress, the distribution of the funds in Fiscal Year 1986 will remain much the same as in 1985.

For the ease of presentation and man-

Experiments envisioned include demonstrations of space-based sensors emplaced at high altitude (illustration) for boost phase surveillance and tracking, and a midcourse surveillance system that will enable detection, tracking and discrimination of all objects in low Earth orbit, including ballistic missile warheads, decoys and debris.



Among supporting technologies being investigated in the SDI program is a space-based system for generating high power levels. The artist's concept shows the ST-100 Space Nuclear Reactor Power System being developed under Department of Defense/ Department of Energy/NASA sponsorship.

agement, the program has been broken up into five major program elements or thrusts. The first major thrust is surveillance, acquisition, tracking and kill assessment (SATKA), which encompasses the five previously-mentioned system concepts: boost-phase infrared surveillance system, midcourse infrared surveillance, midcourse laser or radar imaging system, late midcourse to terminal airborne infrared tracking system, and a terminal imaging radar. In addition to the pursuit of technologies leading to major experiments conducted in support of each of these concepts, significant effort is underway also to gather radar and optical data on missiles and backgrounds and to investigate common technologies such as signal processing and the development of imaging algorithms. The Army and Air Force will each execute about 40 percent of the funds for surveillance, acquisition, tracking, and kill assessment in FY 86.

The second major thrust is directed energy weapons, with primary emphasis within the DoD upon space-based chemical lasers, ground-based excimer and free electron lasers, and space-based neutral particle beams. The Air Force is by far the largest executor of the directed energy work in FY 86.

The third major thrust is in the kinetic energy weapons area, which includes the concepts for space-based kinetic kill vehicles, space-based hypervelocity launchers, and ground-based endo- and exoatmospheric hit-to-kill interceptors previously discussed. All of the concepts are supported by major technology efforts in terminal homing, chemical and electromagnetic propulsion, fire control and acquisition and tracking. The Army will execute the largest portion of the kinetic energy weapons thrust in FY 86.

The fourth major thrust is systems analysis and battle management, where the main efforts are system and battle management architectures and the associated communications, command and control technologies. This area has received much attention lately with the award of 10 one-million-dollar contracts for alternate architecture studies which will identify the key trade-offs of various total-system designs. The results of these studies will help General Abrahamson guide the individual technology programs toward the achievement of overall, integrated system objectives. The funds here are divided almost equally among the Army, the Air Force and the SDIO, with the services' primary thrust in technologies and the SDIO's in systems analysis.

The fifth major thrust includes an assortment of high priority technologies which individually do not take a sufficiently large fraction of the program's funding to warrant a separate program element for each. This includes major efforts in space system survivability technology, lethality and target hardening testing, space prime power from tens of kilowatts to megawatts, and space logistics with particular emphasis on launch, orbit transfer and on-orbit support. The Air Force is conducting most of the survivability, space power and space logistics work with the Defense Nuclear Agency directing the lethality and target hardening tests with assistance by the Air Force, Army, and DoE.

A considerable amount of growth in each of these five major thrust areas has been requested in the President's budget for Fiscal Year 1986. This growth is attributable to the fact that the many technologies which make up the Strategic Defense Initiative had each reached a point where they were ripe for exploitation. It is common for the funding of an emerging technology to grow rapidly as it is experimentally applied to potential weapon system concepts after an extended period of low-level research.

The goal for the Strategic Defense Initiative was eloquently established by President Reagan in March 1983, when he challenged all of us in the scientific community to create a means for rendering ballistic missiles impotent and absolete.

The goal of the Strategic Defense Initiative has not changed at all since the President's March 1983 speech, even though the understanding of that goal by the program's opponents may have changed. The President's original goal still drives this research and technology program, with the need for the United States "to get started now", as he stated in his State of the Union address.

By JAMES J. HAGGERTY

1986: A BIG YEAR IN SPACE

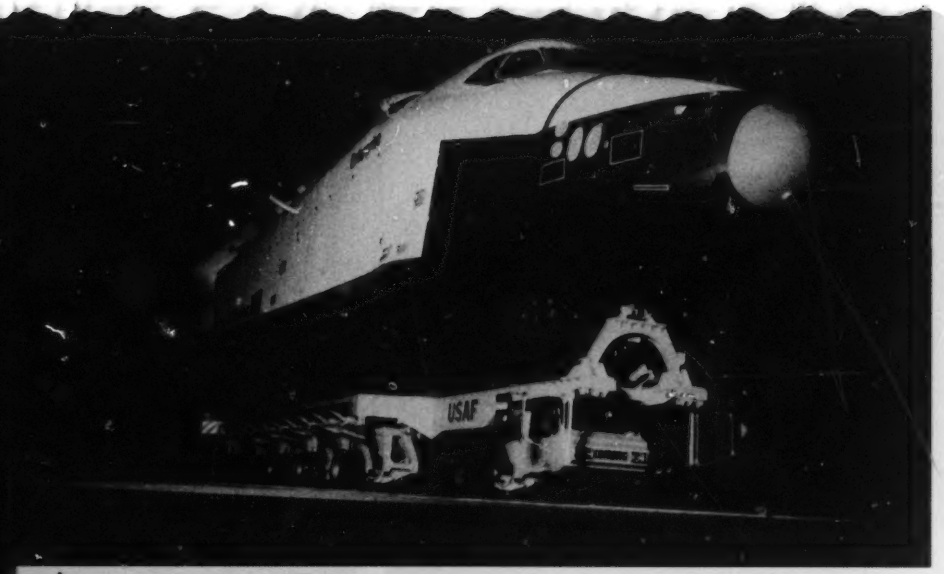
U.S. space accomplishments in 1984 marked the most eventful year of the Shuttle era, perhaps the most spectacular year since the first manned lunar landings in 1969. The year was highlighted by the debut of the backpack one-man spacecraft, Martin Marietta's Manned Maneuvering Unit (MMU); the subsequent use of the MMU in history's first recapture of an orbiting satellite; and the follow-up retrieval of two expensive communications satellites earlier stranded in improper orbits. The near-flawless performance of those difficult missions won the Collier Trophy for a NASA/industry/astronaut team as the year's most significant achievements in aeronautics/astronautics.

But wait 'til next year.

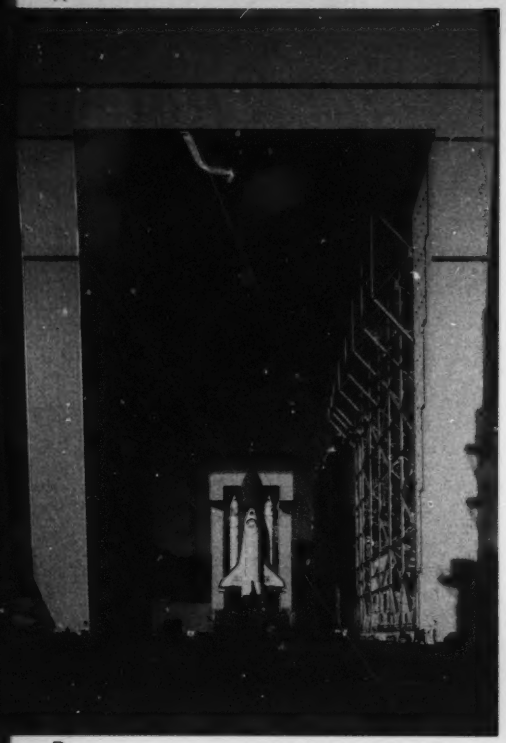
Over the 12-month span beginning in January, a number of major space programs in development for a decade or more will come to fruition if all goes as currently planned. Although there will be plenty of excitement, the year's happenings will not match the first steps on the moon for sheer drama; but in terms of scientific potential and capability advancement, 1984 may well surpass the Apollo year 1969. Among the projected highlights are:

- The start of Space Shuttle operations at Vandenberg Air Force Base, California and the first polar-orbiting Shuttle flight.
- A fly-by of the planet Uranus, never before explored by spacecraft and only dimly observed from Earth.
- An analytical look at Comet Halley from a new Shuttleborne observatory.
- Delivery to orbit of the most advanced space observatory ever built, potentially the most dramatic advance in astronomy since the invention of the telescope.
- Commencement of a multiyear mission that will eventually take an international spacecraft around the poles of the Sun.
- Launch of a highly sophisticated two-element spacecraft designed to make a comprehensive exploration of the planet Jupiter and perhaps—it's an en route option—the first close encounter with an asteroid.

These and other planned developments of 1986 are amplified in the illustrated summary that follows.



A



B

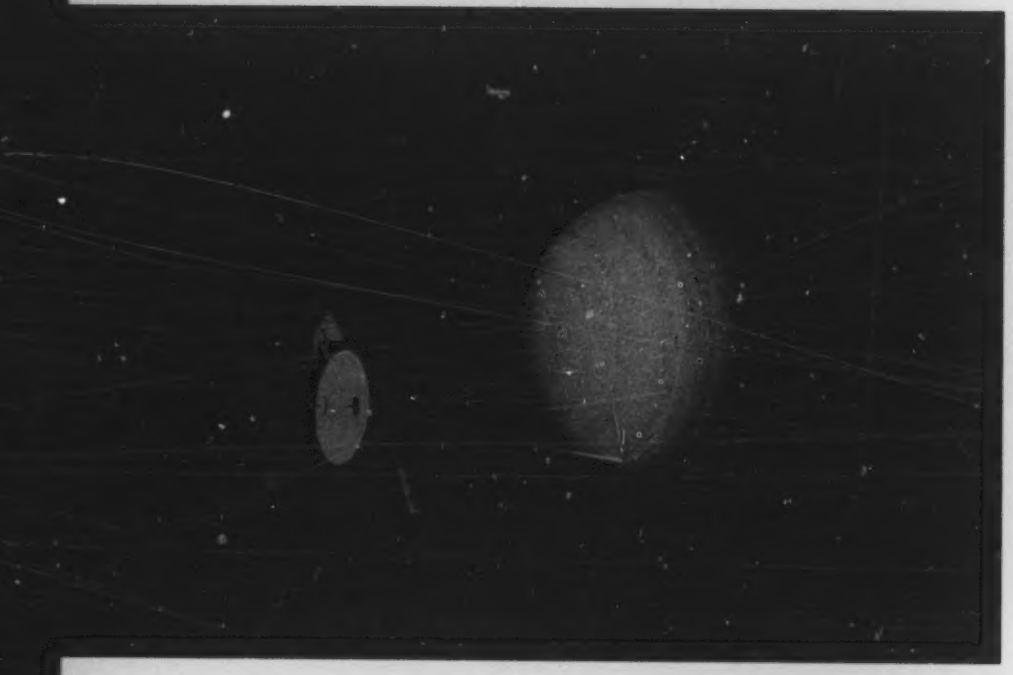
NEW SHUTTLE BASE

In March 1986, the Space Shuttle will make its first flight from the West Coast space launch complex at Vandenberg Air Force Base, California. The Orbiter *Discovery* will be directed into polar orbit, a first for the Shuttle; polar launches are impracticable from the existing launch base at Kennedy Space Center, Florida. Both Air Force and NASA Shuttle missions requiring polar orbit will be launched from Vandenberg, significantly increasing Shuttle capability.

Operated by the USAF Strategic Air Command's 1st Strategic Aerospace Division (1 STRAD), the Vandenberg facility is designed to support six to 10 Shuttle flights a year in the 1980s, eventually 20 a year.

In January of this year, 1 STRAD began a facility verification program that involves "fit and function" checks of Shuttle hardware, payload operations and launch processing simulations to ensure readiness for the first flight. On February 1, the Vandenberg team completed the first "stacking" of a complete Shuttle—the Orbiter, the two solid rocket boosters and the external fuel tank—known as the Facility Verification Vehicle (FVV). The Orbiter used on the FVV is the prototype *Enterprise*, which is not equipped for space flight. Photo A shows the *Enterprise* being delivered to Vandenberg's Space Launch Complex Six by a 76-wheel transporter. At the Shuttle Assembly Building it is craned into place with the previously stacked booster and tank (Photo B). In Photo C, the complete stack is undergoing checkout on the pad.

C

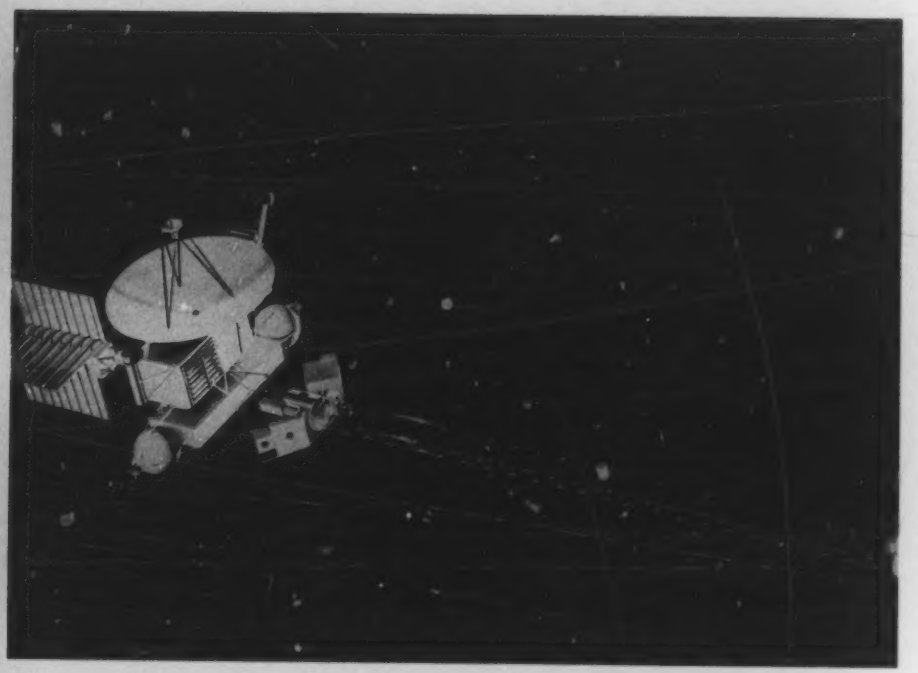


VOYAGER AT URANUS

Uranus, the seventh planet of the solar system, orbits the Sun at a distance of 1.8 billion miles, thus is only faintly visible to Earth telescopes. A close look at this little known planet is of prime scientific importance. Voyager 2, which departed Earth eight years ago and returned volumes of information about Jupiter and Saturn, will provide the first closeup views of Uranus next January, when it passes within 64,000 miles of the planet. If Voyager is still functioning after that encounter, it will continue toward Neptune, a billion miles farther, for a 1989 rendezvous.

SHUTTLEBORNE OBSERVATORY

March 1986 will see the debut of a new Shuttle-based observatory called *Astro*. Intended for service on a number of Shuttle missions, it is a system of three imaging telescopes designed to study celestial objects in ultraviolet light, which is largely invisible to ground telescopes because it is absorbed and filtered by Earth's atmosphere. The initial flight has been timed to coincide with Comet Halley's close approach to the Sun; Astro's instruments will measure ultraviolet wavelengths and intensities as a means of determining the comet's composition and structure. For this seven-day mission, Astro will be fitted with cameras for photographing Halley in visible as well as ultraviolet light.



ULYSSES

In May 1986, the Space Shuttle will launch a pioneering spacecraft named Ulysses into a vast unexplored region of space known simply as "out of the ecliptic." The ecliptic is an imaginary extension of the Sun's equator. Earth and all the planets revolve about the Sun close to this plane, so the space above and below the imaginary equatorial plane has never been visited by spacecraft. Ulysses will be boosted into a trajectory that will take it on a five-year jaunt through interplanetary space and around the poles of the Sun. The mission is a joint effort of NASA and the European Space Agency (ESA). ESA is developing the spacecraft and half of the scientific payload; NASA is providing the other half and the spacecraft's power generating system.

GALILEO

To be Shuttle-launched in May 1986, Galileo is a two-element spacecraft intended to amplify earlier-acquired scientific information about the planet Jupiter. One element is an entry probe which, protected by a heat shield from temperatures expected to reach 14,000 degrees Fahrenheit, will descend into Jupiter's atmosphere and report first-hand data. In the accompanying artist's concept, the probe (the top-shaped object at left) is being released from the primary spacecraft. The main element will become an artificial Jovian moon, transmitting data and images of Jupiter and its satellites for 22 months. Hughes Aircraft Company and General Electric Company are building the probe, Jet Propulsion Laboratory the main spacecraft. Galileo may also make the first encounter with an asteroid; that's an option that NASA controllers can decide after launch. If the option is exercised, the encounter will take place in December 1986, one more event of the big year in space.

SPACE TELESCOPE

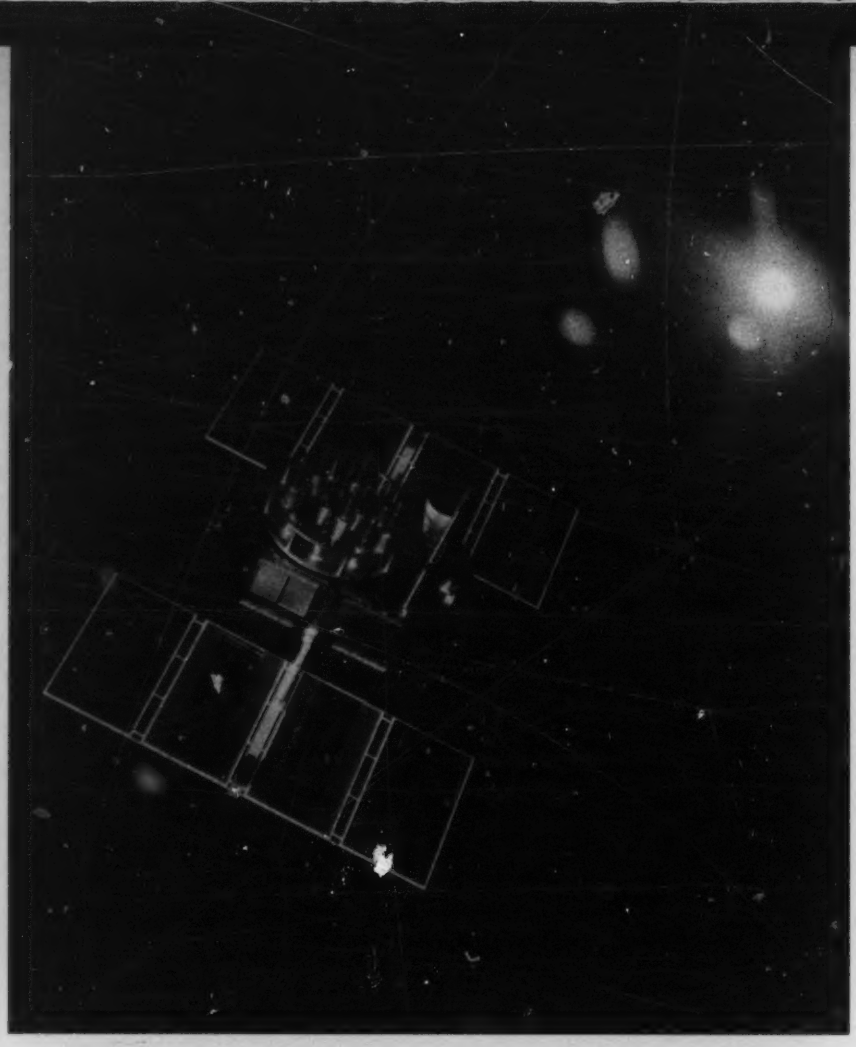
Potentially the greatest advance in astronomy since the 17th century invention of the telescope, the Hubble Space Telescope will be launched into low Earth orbit in August of 1986. The 43-foot long observatory, which will become the largest scientific payload ever sent into orbit, will operate at an altitude of 320 miles, free of atmospheric distortions that limit the vision of ground-based telescopes. Thus it will expand man's view of the cosmos about 350 times, literally allowing a look back in time some 14 billion years. The Optical Telescope Assembly was developed by Perkin-Elmer Corporation; Lockheed Missiles & Space Company is building the Support Systems Module and integrating the complete spacecraft.

UPPER STAGES

The most powerful upper stage booster designed for Shuttle use will make its initial flights on the Ulysses and Galileo missions. Known as Centaur G Prime (Photo A) it is one of two Centaur versions being developed by General Dynamics Corporation for NASA and Air Force programs. It is capable of boosting seven ton payloads into geosynchronous orbit or sending as much as 17½ tons into interplanetary trajectory. Another advanced upper stage – Orbital Science Corporation's Transfer Orbit Stage (TOS) – will become available for Shuttle use late in 1986; it is designed to boost medium-size payloads in the 6,000-13,000 pound range. TOS (Photo B) is being developed, in cooperation with NASA, as a commercial enterprise, with Martin Marietta Denver Aerospace as prime contractor to OSC. The TOS development team also includes United Technologies Chemical Systems Division and the Strategic Avionics Division of Honeywell Inc.

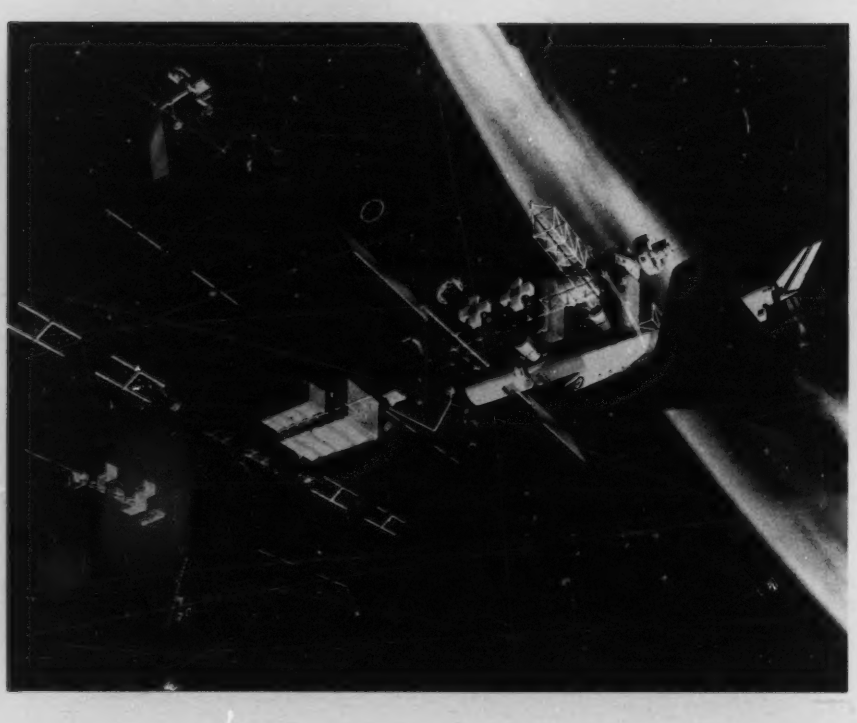
A

B



NAVSTAR

The Navstar Global Positioning System (GPS) is a network of navigation satellites and ground equipment designed to provide precise position fixing for weapons platforms. It represents an enormous advance in weapons delivery capability in that it provides space reference points for determining the location of a military craft/vehicle with a degree of accuracy never before attainable. The Air Force is testing the system with an interim network of six developmental satellites. In the fourth quarter of 1986, the USAF will launch the first advanced Block 2 satellites of the operational GPS, which will have 18 satellites in six different orbital planes; this will allow receiver-equipped Department of Defense units anywhere on Earth to fix their positions within 50 feet. The Navstars will be Shuttle-launched, three at a time, from Vandenberg Air Force Base. Full operational capability of the GPS, requiring all 18 satellites, is expected by the end of 1988.



SPACE STATION

By the end of 1986, contractor teams will have essentially completed the Phase B Space Station definition and preliminary design studies initiated in April of this year. That will pave the way for the big step: final design determination and the start of hardware fabrication in 1987/88. Some 80 contractors, organized into eight teams, are studying various aspects of the station on a competitive basis. NASA has not officially stated a date for initial occupancy of the station, but planning is directed toward launching the first—and possibly several—of the eight Shuttle missions required to assemble the station in 1993.

New Goals for Aeronautical R&D

Superefficient subsonic jetliners, 2,000-mile-per-hour passenger transports, and transatmospheric aircraft capable of cruising at the top of the atmosphere and flying into orbit—these are among the goals set forth by an Aeronautical Policy Review Committee established by Dr. G. A. Keyworth, II, Presidential science advisor and Director of the Office of Science and Technology Policy (OSTP).

Keyworth stressed that, in the face of strong and growing challenges from abroad, lasting U.S. aeronautical leadership will be maintained only by the vigorous application of a traditional American strength: innovative technology. There are, he added, aeronautical opportunities which, if actively pursued, could result in U.S. civil and military aircraft of clear-cut superiority, aircraft whose technical excellence could more than overcome foreign competitive approaches.

The task he assigned the Aeronautical Policy Review Committee was "to lay out a visionary roadmap that truly exploits (aeronautical) technological potential." Created in 1983, the committee responded with a report, released in April, that proposes three broad national goals to clarify and focus the direction of U.S. aeronautical R&D. The goals, in time-phased order of attainment, are:

- ***Subsonics Goal***

Intended to build "trans-century renewal" of America's technological strength, the subsonics goal envisions advancing technologies applicable to a variety of subsonic aircraft. Most of these technologies could mature in the 1990s to lay a foundation for a new generation of highly efficient, affordable aircraft operating in a modernized National Airspace System. Types would include short, medium and long range transports and rotorcraft incorporating advanced drag reduction techniques, high speed turboprop engines, all-composite structures, high lift aerodynamic systems and flight control/guidance improvements.

Achievement of the subsonics goal would enable U.S. manufacturers to capture "immense civil aircraft opportunities by technologically superseding foreign competitive challenges." At the same time, the new technologies would support development of advanced military aircraft capabilities.

- ***Supersonics Goal***

This goal involves development of pacing technologies for sustained supersonic cruise capability with long distance efficiency, which would permit linking the U.S. with the farthest reaches of the Pacific Rim in four to five hours. Keyworth emphasized that the Administration has made no commitment to a supersonic transport but "we are laying the groundwork, both in NASA and DoD, in the fundamental technologies essential for any future efforts in supersonic flight."

Such technologies include supersonic laminar flow control, major improvements in variable-cycle engine efficiency, noise abatement and lightweight, high-temperature structures. Successful integration of these technologies could make possible 600-passenger transports with speeds up to Mach 3.2 over a range of 5,500 miles with three times the fuel efficiency of current supersonic aircraft. Again, the new technologies would benefit military supersonic flight, through enhancements in basing flexibility, long distance responsiveness and survivability.

- ***Transatmospherics Goal***

Research in this area would be directed toward developing a capability for routine cruise and maneuvers into and out of the atmosphere with takeoff and landing from conventional runways. Vehicles of this type depend on further technological progress in propulsion, materials and "intelligent" integrated flight controls. Research would draw upon progressive subsonic, supersonic and hypersonic advancements in aeronautics, as well as Space Shuttle experience. Applications of transatmospheric vehicles range from regular access to space to rapid point-to-point transportation.

The report states that such a research program will influence long range options for both aeronautics and space and will be significant to U.S. civil/military aircraft technology leadership in the 21st century.

America's future in aeronautics, says the report, demands much more than a "business as usual" attitude. Citing barriers that impede technological advancement in both the public and private sectors, the committee suggested corrective actions that "should be pursued without delay," among them:

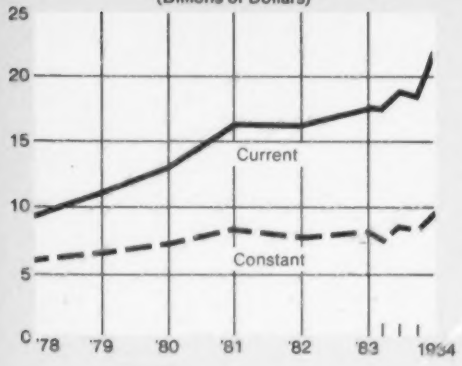
- Federal contracting procedures should be restructured to reflect a greater distinction between the procurement of research and technology and the procurement of hardware.
- Regulatory policy should encourage cooperative efforts for technology development among U.S. companies.
- Federal tax legislation should adequately stimulate private investment in timely technology development.

Chaired by retired Boeing vice president John E. Steiner, the Aeronautical Policy Review Committee included representatives of McDonnell Douglas Corporation, Garrett Turbine Engine Company, Rockwell International, Fairchild Industries, General Electric Company, Bell Helicopter Textron, Lockheed Corporation, The Boeing Company, the Air Transport Association and Massachusetts Institute of Technology. Government agencies represented included the Departments of Defense and Commerce, NASA, the Federal Aviation Administration and OSTP.

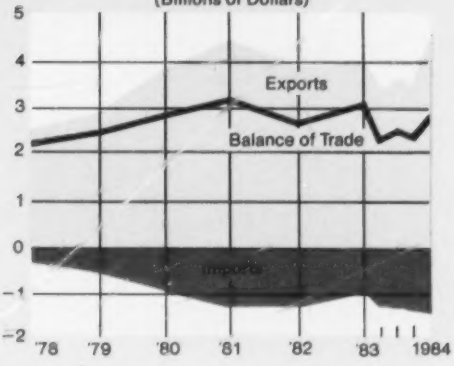
AEROSPACE ECONOMIC INDICATORS

CURRENT

Quarterly Aerospace Shipments
(Billions of Dollars)

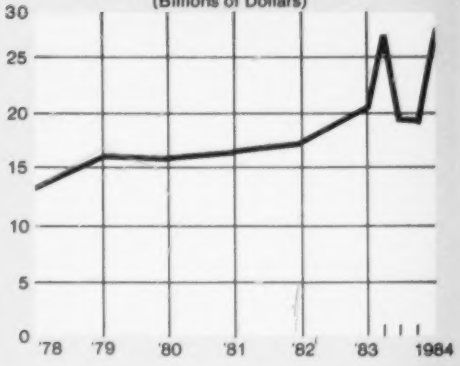


Quarterly Aerospace Foreign Trade
(Billions of Dollars)



OUTLOOK

New Orders—Quarterly Average
(Billions of Dollars)



ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	YEAR AGO	LAST QUARTER	LATEST QUARTER 4th QTR 1984
AEROSPACE MANUFACTURING						
Shipments	Billion $	Quarterly	6.3	18.4	18.7	21.9
New Orders	Billion $	Quarterly	6.5	26.1	19.3	27.4
Backlog of Unfilled Orders	Billion $	End of Quarter	31.4	103.3	114.8	120.3
Inventories	Billion $	End of Quarter	8.7	27.7	32.7	32.4
Capacity Utilization	Percent	Quarterly	77.5	70.4	76.5	76.5
DEPARTMENT OF DEFENSE						
Aircraft Procurement Obligations	Million $	Quarterly	1,986	9,397	7,251	12,478
Missiles Procurement Obligations	Million $	Quarterly	726	2,336	2,392	3,319
Aircraft Procurement Outlays	Million $	Quarterly	1,741	5,815	5,901	6,298
Missiles Procurement Outlays	Million $	Quarterly	664	1,821	1,529	2,292
NASA R&D AND SFCDC[a]						
Obligations	Million $	Quarterly	780	1,912	1,636	2,313
Expenditures	Million $	Quarterly	789	1,626	1,341	1,680
FOREIGN TRADE						
Exports, Total	Million $	Quarterly	1,037	3,695	3,604	4,203
Civil	Million $	Quarterly	742	2,490	2,136	2,703
New Commercial Transports	Million $	Quarterly	347	970	600	1,045
Imports, Total	Million $	Quarterly	119	998	1,235	1,267
Civil	Million $	Quarterly	NA	842	992	1,032
Balance of Trade, Total	Million $	Quarterly	918	2,697	2,369	2,936
Civil	Million $	Quarterly	NA	1,648	1,144	1,671
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	1,171	1,221	1,252
Aircraft (SIC 372)	Thousands	End of Quarter	650	585	611	626
Missiles & Space (SIC 376)	Thousands	End of Quarter	114	149	157	163
FINANCE						
Profits (after tax) Based on Sales						
Aerospace	Percent	Quarterly	2.7	4.0	3.3	4.3
	Percent	Annually**	2.7	3.5	4.0	4.1
All Manufacturing	Percent	Quarterly	4.8	4.5	4.5	4.1
	Percent	Annually**	4.8	4.1	4.7	4.6
Plant & Equipment Expenditures	Billion $	Calendar Year	1.03	2.91	NA	3.55
GNP DEFLATOR (1972=100)	Index	Quarterly	95.9	218.2	224.6	226.1
	Index	Annually**	95.9	215.3	221.4	223.4

*1966-1975 quarterly averages are computed as one-fourth of annual averages.
**Annual data are computed as the sum of the previous four quarters.
a Effective 4th Qtr 1983, includes new budget category of 'Space Flight, Control & Data Communications.'
NA Not Available

Source: Aerospace Industries Association

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AIA

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Aeronca, Inc.
Allied Corporation
Aluminum Company of America
Avco Corporation
The Boeing Company
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  Delevan Corporation
Criton Technologies
E-Systems, Inc.
Ex-Cell-O Corporation
FMC Corporation
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Gates Learjet Corporation
General Dynamics Corporation
General Electric Company
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  Allison Gas Turbine Division
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  ITT Aerospace/Optical Division
  ITT Avionics Division
  ITT Defense Communications Division
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  ITT Gilfillan
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